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TITLE: TO IMPROVE IRON ORE RECOVERY AT SCULLY MINE - PHASE III (Canada/Newfoundland Mineral Development Agreement)

Final Report
by:

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1.0 SUMMARY

PHASE III of the Mineral Development Agreement (MDA) involved pilot plant testing of the grinding and spiral circuits, on-site,at the Scully Mine Ore Dressing Plant,Labrador, Newfoundland.Based on the recommendations of PHASES I and II spiral middlings regrind and finer mill sizing were investigated as potential ways of improving iron unit recovery.

A middlings regrind flowsheet was setup on mill #4,establishing this as the prototype mill line.Comparative testing indicated that middlings regrind increased spiral iron unit recovery by 1.68 percentage points.It was therefore recommended that all six mill lines be configurated to regrind spiral middlings.

Progress was made in the achievement of finer mill sizing with the installation of a finer trommel (4 mm,rubber) in conjunction with slightly finer (1.5 mm) Polydeck sizing screens.This first step was a success as sizing screen efficiency improved with no reduction in mill throughput.It was suggested that further reduction in slot size to the recommended 1.0 mm not proceed until a 4 mm urethane trommel is tested and the mill basesment cleanup water is removed from the milling circuit.

2.0 INTRODUCTION

This project was sponsored by the Canada Center for Mineral and Energy Technology (CANMET) in Ottawa,under the Canada Newfoundland Mineral Development Agreement.The objective of this investigation is to explore the potential for and to find ways of improving iron recovery at the Scully Mine Ore Dressing Plant, Labrador,Newfoundland.

The scope of work was divided into four phases:

PHASE I - Quantitative mineralogical study of selected concentrator products.

PHASE II - Bench scale testing for grinding and spiral circuit flowsheet development.

PHASE III - Pilot plant tests based on the results of Phase II.

PHASE IV - Optimization of the protoyype circuit.

This report is the final report for Phase III of the project and summarizes the results of pilot plant testing carried out on-site at the Scully Mine Concentrator.

3.0 TECHNICAL BACKGROUND

The recommendations from both PHASE I and PHASE II were used to develope a strategy for PHASE III pilot plant testing. As a brief review the important conclusions and recommendations of the first two phases of this project are outlined below :

3.1 PHASE I

Phase I was completed at the Research and Productivity Council,Fredericton,N.B.and involved an intensive image analysis study of selected samples.Eight mill product samples from the Scully Concentrator and five samples from bench tests carried out by the Ontario Research Foundation (Phase II) were studied.

The objectives of the investigation were to determine mineral characteristics that affect iron and manganese recoveries.An improvement in iron recovery and decrease in manganese concentration were the end goals.

The final report on Phase I had several important conclusions :

A) In the spiral middlings sample over 25% of the iron bearing minerals are in an unliberated form (locked particles).

B) To liberate manganese minerals to separate them from iron oxides, in any mill product, would require grinding that product to minus 400 mesh.Free grains of manganese minerals will tend to concentrate with iron minerals in the spiral circuit.

C) From the Ontario Research Foundation (ORF) samples,the -28 mesh mill product sample showed a higher level of iron mineral liberation compared to the -20 mesh mill product sample.

3.2 PHASE II

Phase II bench scale testing was carried out at the Ontario Research Foundation (ORF),Mississauga,Ontario. Approximately 26 tons of Scully Concentrator mill trommel discharge were shipped to this facility.

The objective,of PHASE II, was to optimize the existing spiral concentrator circuit.The investigation took place in a series of task assignments to determine if improvements could be made to the circuit either in new equipment installation or through changes in the existing flowsheet.

The two most important results from this phase of the investigation are as follows :

A) Respiralling a reground spiral middlings improved the recovery and grade of the spiral concentrate.A recommendation was made to test at the pilot plant level a middlings regrind circuit.

B) Grinding and spiral testwork with both -20 and -28 mesh closing screens showed a marginal improvement in overall iron recovery with the finer screens.Manganese values in the spiral concentrate were also reduced with the finer spiral feed.

4.0 PROCEDURE

The recommendations from Phase I and Phase II provided valuable information essential for the formulation of the pilot plant test program to be undertaken at Scully Mine.These first two phases indicated that increased liberation of mill circuit products could result in higher iron unit recoveries.More specifically, (a) a regrind of the spiral middlings and (b) finer mill sizing were the recommended changes that should be investigated further on a pilot scale.

At the Scully Mine mill #4 (one of six independent mill lines) was selected as the prototype mill line.This circuit was set-up for pilot plant testing.Comparative testing with other mill lines enabled the effects or changes on the test circuit to be easily evaluated.

A description of the two test programs (middlings regrind, finer mill sizing) is given below:

4.1 Regrind of Spiral Middlings

As a brief review,the original spiral circuit flowsheet at Scully Mine consists of a two-stage circuit with rougher and cleaner stages.The spiral recirculating load consists of the rougher "middlings" collected from the #15 port at the bottom of the rougher spiral column and the cleaner spiral "tailing". These two streams are combined,then cycloned with the underflow being recirculated as rougher spiral feed.Cyclone overflow reports to the reuse water thickener.

To establish a middlings regrind circuit the cyclone underflow,on mill #4, was redirected (by a piping change) to the recirculating pumpbox.From there the middlings was pumped back into the primary autogenous mill for regrinding.

This protoype circuit was evaluated by comparing its performance with the adjacent mill #3.An extensive sampling program was undertaken to determine the effects of regrinding the spiral middlings on spiral circuit performance.The final report of this testwork,included in APPENDIX I,gives a much more detailed account of the test procedure.

4.2 Finer Mill Sizing

As a brief review, mill classification consists of both trommel and sizing screens.Ground ore passes through the mill discharge grates and spills onto a trommel screen attached to the mill.The trommel undersize,by gravity, becomes sizing screen feed.The oversize from both the trommel and sizing screens is returned to the mill,while the sizing screen undersize is taken as spiral feed. The plant standards are 5 mm slot openings for the trommel panels and 1.6 mm for the sizing screens.

A loss in screening efficiency is normally associated with a decrease in slot size.If this loss could be minimized there would be a greater chance of success when implementing finer screening.To achieve this the existing screens would have to be optimized before finer media was installed.Therefore the goal of achieving finer mill sizing followed a two step approach:

1) Optimize the existing screening equipment.

2) Install finer media to achieve finer mill sizing.

To improve the existing screening system all six sizing screens on mill #4 were outfitted with Polydeck Screen Corporation's modular screen panels.In addition the existing Derrick screen drives were replaced with Tyler drives.The Polydeck screen panels have 20% more open area than the plant standard panels while the Tyler drives had been shown in previous testwork to be superior to the Derrick drives (see APPENDIX II).

The test procedure for reducing the media slot size involved two subsequent steps:

1) Testing of a finer slot opening on the mill trommel screens (plant standard 5 mm)

2) Testing of a finer slot opening on the mill sizing screens (plant standard 1.6 mm).

On mill #4 a complete set of 4mm trommel panels were installed as a first step.In addition it should be noted that the Polydeck panels installed on mill #4 also had a slightly finer slot opening of 1.5 mm,a positive contribution towards the goal of finer screening.To evaluate the performance of the finer trommel and the improved sizing screens,mill #4 was comparatively tested against mill #3.

5.0 RESULTS AND DISCUSSION

5.1 Middlings Regrind

The final report of the pilot plant testing of the middlings regrind flowsheet is included in APPENDIX I.This report gives a detailed account of the test procedure and the effect of middlings regrind on the grinding and spiral circuits.

Highlighting the results:

1) On the middlings regrind circuit a reduction in the amount of +35 mesh material was observed throughout the spiral circuit as coarse locked middlings particles were being liberated by regrinding.

2) No overgrinding of middlings material was observed.

3) The regrind circuit increased spiral weight and iron recoveries by 1.23 and 1.68 percentage points, respectively,as compared to the standard circuit.

4) Lab scale testing using spiral concentrate from the regrind circuit indicated that high tension separation should also be improved,as a result of the greater degree of liberation of the middlings. (At the Scully concentrator spiral concentrate is upgraded in a high tension circuit to produce a final concentrate.)

5) Regrinding the middlings produced a slight increase in spiral concentrate manganese grade.

The results showed that further liberation of the middlings was achieved by returning this material to the primary mill for regrinding.Plant scale testing confirmed the results from PHASE I and PHASE II by showing that spiral circuit iron recovery would improve on a regrind circuit.

It was recommended that all six mill lines at the Scully Mine be converted to middlings regrind flowsheets.

5.2 Finer Mill Sizing

A preliminary evaluation of a Polydeck screen deck at the Scully Mine had indicated that this screen gave a higher screening efficiency as compared to the plant standard.The report on this testwork is included in APPENDIX II.The conclusions from this report suggested that a Polydeck screen deck outfitted with

a Tyler drive should offer the best screening system.Based on this preliminary work the six sizing screens on mill #4 were outfitted with this Polydeck/Tyler combination.

Installion of the 4 mm trommel on mill #4 was the first step towards achieving a finer mill grind.The final report on the finer trommel in combination with the improved Polydeck/Tyler sizing screens is included in APPENDIX III.

Highlighting the results:

1) The 4 mm trommel caused no operational problems or reduction in mill throughput when operating mill #4 under the middlings regrind flowsheet.

2) During the test period the sizing screens on mill #4 had an average efficiency of 92.8% compared to 82.3% on mill #3.

3) The effect of mill basement cleanup water, which is pumped back into the mills, on sizing screen performance was also studied.This excess volume of water was shown to have a negative effect on sizing screen performance.

The biggest concern when considering finer mill sizing is whether or not a reduction in mill throughput will be the end result from an increased recirculating load.At the Scully Mine this would be an unacceptable circumstance as production goals would not be met.As a result,a step-by-step incremental reduction in slot size is the logical method of achieving a finer grind.

The 4 mm trommel in combination with the slightly finer sizing screens (Polydeck = 1.5 mm,plant standard = 1.6 mm) has proven very successful as a first step.The next step will be a further reduction in sizing screen slot size.PHASE II testwork indicated that improved spiral iron recovery would be achieved with a -28 mesh grind.To achieve this size split the slot size on the sizing screens would have to be reduced to 1.0 mm.

Before any further reduction in slot size is considered two important changes in the existing circuit must first be completed.These changes,described in detail in APPENDIX III, are as follows:

1) A 4mm trommel made from urethane should be tested. The trommel tested under the present study was made from rubber which for test purposes is cost effective.With success of the 4 mm slot size obtaining the more expensive urethane panels can now be justified.

2) The mill basement cleanup water should be removed from the mill circuit.

Both the above items are presently in various stages of completion at the Scully Mine.A complete set of 4 mm urethane panels has been approved for testing under the Improvement Project Request (IPR) procedure and should be obtained in the near future.In addition,the engineering is underway to design a pump/cyclone system to remove the large volumes of mill basement cleanup water from the grinding circuit.

6.0 CONCLUSIONS AND RECOMMENDATIONS

Pilot plant testing showed that a middlings regrind circuit increased spiral plant weight and iron recoveries by 1.23 and 1.68,percentage points,respectively as compared to the standard circuit.No reduction in mill throughput or overgrinding of middlings material was observed.It was therefore recommended that all six mill lines at Scully Mine be converted to middlings regrind flowsheets.

The first step in obtaining a finer mill grind was achieved with the success of a 4 mm trommel in combination with 1.5 mm Polydeck sizing screens.An improvement in sizing screen efficiency was observed without any limitations on mill throughput.A further reduction in slot size to the recommended 1.0 mm (28 mesh) should not proceed until 4 mm urethane panels have been tested and the mill basement cleanup water has been removed from the grinding circuit.

7.0 FUTURE PLANS

1) Based on the findings from PHASE III of the MDA three mill lines have been converted to middlings regrind flowsheets.The work was completed under a 1989 Capital Appropriation valued at $315,000.The payback on this project of 1.07 years was based on improved iron unit recovery.Funding to convert the remaining three mill lines is being requested under a 1990 Capital Approriation.

2) The work necessary to remove the mill basement cleanup water from the milling circuit will also be completed under funding from a 1989 Capital Appropriation.This work is presently in progress.When this is complete and when new 4 mm urethane trommel screens have been installed on mill #4 testing of finer mill grind will resume.

3) The final phase of the MDA,PHASE IV,which is presently underway,involves optimization of the prototype circuit. At present Comdale Technologies,Toronto,Ontario,a subcontractor, are developing an expert control system for the grinding and spiral circuits.

LIST OF ATTACHMENTS

APPENDIX I - Regrinding the Spiral Middlings (Final Report) Process Development Report #861

APPENDIX II - Evaluation of Polydex Mill Sizing Screens Process Development Report # 844

APPENDIX III - Effect of 4MM Trommel Screens and Mill Cleanup Water on Sizing Screen Performance Process Development Report # 889

SCULLY MINE
WABUSH MINES

PROJECT NUMBER: 861
PROCESS DEVELOPMENT DEPARTMENT
P.CLEYLE
December 15, 1988

REGRINDING THE SPIRAL MIDDLINGS - PHASE IV

(FINAL REPORT)

SUMMARY

A middlings regrind circuit established on Mill Line # 4 under a 1987 Capital Appropriation was evaluated to determine the metallurgical benefit of regrinding the spiral middlings.

During the test period, middlings regrind had no adverse affects on the operation of the mill. No reduction in mill throughput or sizing screen efficiency was observed.

Compared to the standard circuit,with middlings regrind a reduction in the amount of +35 mesh material was observed throughout the spiral circuits as coarse locked middlings particles were being liberated by regrinding. No overgrinding of middlings material was observed.

With a reduction in coarse material both the spiral and high tension processes were improved. Plant testing showed that a regrind circuit increased spiral weight and iron recoveries by 1.23 and 1.68 percentage points, respectively as compared to the standard circuit. Regrinding middlings produced a slight increase in spiral concentrate manganese grade; during one series of tests the regrind circuit averaged 2.08% Mn compared to 1.98% from the standard circuit. Silica rejection in high tension was shown to be more efficient when treating spiral concentrate produced from a regrind circuit.

It was recommended that all six mill lines at Scully Mine be converted to middlings regrind circuits.

1.0 INTRODUCTION:

The present spiral circuit flowsheet at Scully Mine is illustrated in Figure 1. The two-stage circuit consists of rougher and cleaner stages. The spiral recirculating load consists of the rougher "middlings" collected from the # 15 port at the bottom of the rougher spiral column and the cleaner spiral "tailing". These two material flows are combined then classified by the rougher middling/ cleaner tailing cyclone with the underflow reporting to the first stage spiral feed pumpbox and the overflow reporting to the reuse water thickener.

The cyclone underflow consists of fine heavy particles, coarse light particles and unliberated particles. For simplification, the cyclone underflow material will be called "spiral middlings" throughout the remainder of this report. The unliberated particles (locked iron and silica particles) are mostly found in the coarse fraction (+35 mesh) which can constitute up to 25% of the spiral middlings.

Locked particles are detrimental to spiral recovery and grade because they account for a loss of iron units if they report to tailing and an increase in silica recovery if they report to concentrate. Figure 2 shows typical recovery curves for the spiral plant at Scully Mine . It is clear that optimum spiral performance would be achieved if the spiral feed is closely sized in the -35 +150 mesh range.

Returning spiral middlings to the mill has been shown in the past (Process Development Report # 702) to give additional grinding of this material with a resultant decrease in the amount of +35 mesh material. Therefore, by reducing the amount of coarse material spiral separation efficiency should be improved.

In addition, with a reduction in the amount of coarse locked material in the spiral circuit a superior feed to the high tension circuit should be produced. Figure 3 is a graph of high tension silica recovery by size fraction (Wabush Report No. W-470). Clearly, coarse particles are not efficiently separated in the high tension process, and this leads to high silica recovery in the coarse sizes.

Under a 1987 Capital Appropriation a middlings regrind circuit was established on Mill Line # 4. The present study was initiated to quantify the metallurgical benefit from a plantwide conversion to a regrind circuit.

This report represents the fourth and final phase of the testwork involved in the investigation into middlings

regrind. This report includes all the information collected from Phase 1V testing and includes information presented in the Preliminary Report dated August 25, 1988.

2.0 PROCEDURE:

Two different methods were used to evaluate the metallurgical performance of the regrind circuit established on Mill # 4:

I. The first involved comparing the performance of Mill Line # 4 with that of an adjacent mill line. With this method when sampling over a long period of time (normally an 8 hour shift) it can reasonably be assumed that on average the same type of crude ore type will be fed to each of the two mills.

II. With the second method a regrind circuit was compared to the standard circuit within one mill line. The advantage of this method is that it eliminates the bias effect that small uncontrollable differences between mill lines (screen wear, spiral maintenance, etc.) can have on the test results. The disadvantage is that the crude ore type to one mill can change very quickly destroying the basis for comparison.

The sampling procedure for each of the above methods will be briefly described:

2.1. METHOD I - MILL LINE # 4 vs. MILL LINE # 3.

Mill Line # 3 was chosen as the standard mill line for comparison with the middlings regrind circuit established on Mill Line # 4. The following samples were collected from the spiral circuits of both mill lines on a ninety minute basis and made into daily composites. (During dayshift only).

1) Spiral Total Feed
2) Spiral New Feed (Mill # 3 only)
3) Cleaner Spiral Concentrate
4) Rougher Spiral Tailing
5) Middlings Cyclone Underflow
6) Rougher Spiral Middlings
7) Cleaner Spiral Tailing

It should be noted that a spiral new feed sample was collected from Mill Line # 3 only. When regrinding middlings on Line # 4 it is impossible to collect a new feed sample because crude ore and the spiral middlings are mixed within the mill. For the purposes of this test it was therefore necessary to assume that the new feed collected from Mill Line # 3 was identical to the new feed on Mill Line # 4.

Size analysis was carried out on each of the above composite samples with assays (X-Ray) performed on the heads. Wet chemical analysis for iron was also performed on the spiral new feed, the rougher spiral tailing and the cleaner spiral concentrate samples, for greater accuracy, as this data would be used to calculate weight and iron recoveries.

High tension tests were carried out on the spiral concentrate samples collected from both mill lines. The Carpco laboratory high tension unit was used for the testing. The conditions and settings as shown in Appendix 1, simulate actual plant conditions and were held constant for all of the laboratory tests.

For each high tension test 600g of the spiral concentrate was introduced to the Carpco unit, producing a concentrate middlings and tailing after a single pass. The middlings product was then continuously recycled through the unit until depletion. The concentrate and tailing were weighed and samples of each submitted for iron, silica and manganese analyses.

2.2 METHOD II - MILL LINE # 4: NORMAL CIRCUIT vs. REGRIND CIRCUIT:

Using air-actuated pinch valves the middlings cyclone underflow could be directed to either the spiral feed pumpboxes (standard circuit) or to the recirculation pumpbox (regrind circuit). The testing method followed the sequence of steps described below:

1) Samples were collected for one hour with Mill # 4 configurated with the standard circuit.

2) The middlings cyclone underflow was diverted to the recirculation pumpbox and the circuit allowed to stabilize for one hour.

3) Samples were once again collected over a one hour period from the regrind circuit.

The samples collected were spiral new feed (standard circuit only), spiral concentrate, spiral tailing and middlings cyclone underflow.

The above method was also used to collect samples around the mill sizing screens so that a comparison of screening efficiency between the normal and regrind circuits could be determined. Four sets of samples, each including sizing screen feed, screen oversize and screen undersize were collected and subject to sieve analysis.

3.0 RESULTS:

3.1 METHOD I - MILL LINE # 4 vs. MILL LINE # 3

Method I testwork involved two series of tests. The first series (Series I) ran from June 14/88 to July 27/88 and included the collection of 18 sample sets. The results of the size analysis and head assays are presented in Tables 1 - 4 and Figures 4 - 6.

On the regrind circuit coarse particles (+35 mesh) are being reduced in size. Spiral total feed, middlings cyclone underflo and cleaner spiral concentrate samples all show less +35 mesh material on the regrind circuit. Figures 4 - 6 graphicall show a shift in the size distribution of these 3 samples from the +35 mesh to the finer size fractions.

From Table 4, for the 18 sample sets the average weight and iron recoveries were 35.91% and 63.71%, respectively, from Mill # 3 and 40.26% and 69.82%, respectively, from Mill # 4. The much higher recoveries from Mill Line # 4 cannot be attributed solely to the regrind circuit, but are caused in part to a difference in the middlings port setting between the two mill lines. For this first series of testing the # 15 rougher port was opened to a 6 setting on Mill Line # 4 and a 2 setting on Mill Line # 3. The reason for testing a different splitter setting will be discussed in a later section.

For the second series of tests (Series II) the # 15 rougher port was set at a 4 setting on both mill lines and twelve sample sets (Sample No's 19 - 30) were collected. The results of the size and elemental analysis of composite samples made from the twelve sets are presented in Tables 5 - 10.

As with the first sample series, the regrind circuit accounts for a reduction in the amount of +35 mesh material throughout the spiral circuit indicating that coarse middlings particles, returned to the mill, are being reground to a finer size. The regrind circuit shows, on average, increases in weight and iron recoveries of 1.23 and 1.68 percentage points, respectively (Table 11).

Table 12 presents the results of the laboratory high tension tests conducted using spiral concentrate from both Mill Lines # 3 and # 4. The spiral concentrate from each of the sample groups (A to D) is a composite sample of 4 out of the 30 sample sets collected under Method I testing (Tables 4 and 11).

Table 13, summarizes the data from Table 12, by showing the silica ratio between the high tension feed (spiral concentr. and the high tension concentrate. Clearly, concentrate from a regrind circuit improves the separation efficiency of the high tension process.

Table 14, gives assays by screen fraction of composite samples of the high tension concentrates produced from sample groups A, B, and C. In all three groups high tension concentrate from Mill Line # 4 shows less +35 mesh material with less silica distributed in this size fraction.

3.2 METHOD II - MILL LINE # 4: STANDARD CIRCUIT vs. REGRIND CIRCUIT

Table 15 presents the results from 8 sample sets (No's 31 - 37) collected from Mill Line # 4 when alternating between the standard and regrind circuits. The average assays of the eight sets show that almost identical spiral concentrate silica grades were produced from both circuits (6.24% SiO2 from the standard circuit and 6.07% SiO2 from the regrind circuit). With a consistently lower iron assay in the tailing the regrind circuit accounts for higher weight and iron recoveries of 1.33 and 2.39 percentage points, respectively.

The average size analysis of the four sample sets taken around the screening circuit are presented in Table 16. The screening efficiency, calculated at 14 mesh, is very similar under both circuits (85.49% from the standard circuit and 86.29% from the regrind circuit).

4.0 DISCUSSION:

4.1 REGRIND CIRCUIT PERFORMANCE

Establishing a regrind circuit on Mill Line # 4 did not cause any operational problems on this mill line. In fact, during the test period Mill # 4 averaged slightly higher new feed tonnage (Tables 4 and 11) as compared to Mill # 3. Therefore implementing a regrind circuit plantwide should not cause any reduction in mill throughput.

Sizing screen performance was virtually unaffected on the regrind mill. Originally, it was expected that screen performa would decrease since the circulating middlings causes an increase in tonnage across the screens. Under Phase II testing a decline in screening efficiency of only 2% was found while the present testwork showed a difference of less than 1% between the regrind and standard circuits (Table 16 shows that the regrind circuit actually had the higher screen efficiency). These differences are so minimal that sampling error may well be the cause. In any case, it can be concluded that screen efficiency does not pose a problem on a regrind circuit.

4.2 SPIRAL CIRCUIT PERFORMANCE:

Returning the spiral middlings to the mill is without question resulting in further size reduction of coarse material, particularly in the +35 mesh fractions.

The effect of regrinding the spiral middlings is best illustrat by the size analysis of the middlings cyclone underflow. (Series I testing Table 1 and Figure 4 and Series II testing Table 5). From Table 5, regrinding reduced the amount of +35 mesh material, in this sample, from 25.42% (Mill # 3) to 18.72% (Mill # 4).

Size analysis of the spiral total feed, spiral cleaner concentr cleaner spiral tailing and rougher spiral middlings produced similar results. In all of these samples there was a reduction in the amount of +35 mesh material on the regrind mill line.

The spiral total feed sample shows more material in the -35 +150 mesh size range on the regrind circuit; 60.92% from Mill # 3 versus 61.40% from Mill # 4. This represents a definite improvement since spiral performance is optimized with feed material in this size range (Figure 2).

Reducing the amount of coarse (+35 mesh) material also reduces material locking, by liberating locked silica and iron bearing particles. Evidence to support this comes from Table 7 which shows the size and elemental distributions by size fraction for the cleaner spiral concentrate. Compared to the standard circuit, the concentrate from the regrind circuit shows less +35 mesh material with higher iron assays and lower silica assays on each of the size fractions above 35 mesh. Regrinding middlings frees locked silica which will then tend to report to spiral tailing. The coarser particles that do report to concentrate will contain less silica and have a higher percentage of iron bearing minerals.

Although much of the middlings material returned to the mill is already -35 mesh, overgrinding of this material is not a problem. The rougher spiral tailing, cleaner spiral tailing and rougher middlings samples (Table 8 - 10) do not show any significant increase in the amount of -150 mesh material or the amount of iron distributed in this size fraction. Particles finer than 35 mesh are essentially in the liberated state and do not tend to be reduced further in size. Regrinding effects mainly the coarse locked particles with the size shift from +35 mesh to the -35 +150 mesh range.

One of the undesirable effects of regrinding middlings is that the manganese grade in the spiral concentrate will be slightly higher as compared to a standard circuit. From Table 11 the average manganese grade in the spiral concentrate was 2.08% from Mill Line # 4 versus 1.98%

from Mill Line # 3. In much the same way as with the iron minerals, regrinding causes a shift in the manganese distribito from the +35 mesh to the -35 +150 mesh fractions (Tables 5-10). As mentioned earlier this is the optimum size range for spiral recovery and therefore more of the manganese, along with the iron minerals, will report to spiral concentrate

4.3 WEIGHT AND IRON RECOVERY COMPARISON:

The first series of tests (Sample No.'s 1 - 18) produced large increases in weight and iron recoveries on the regrind circuit as compared to the standard circuit. The reason for the size of these increases is due to the difference in middlings port settings between the two mill lines; Mill # 4 at a 6 setting and Mill # 3 at a 2 setting. A recommendati from Process Development Project # 702 (Regrinding the Spiral Middlings - Phase I) stated that a wider splitter setting could be employed at the middlings port on a regrind circuit. It was predicted that more iron could be recovered while still producing the same spiral concentrate silica grade.

However, in the first series of tests in this study a middlings port setting of 6 vs. 2 was too large of a difference as the spiral concentrate produced from Mill Line # 4 averaged 7.45% silica compared to only 5.79% from Mill Line # 3. Naturally, recovering more silica has a marked affect on the weight recovery figures and therefore an unbiased comparison of the effect of regrinding middlings cannot be made from this first series of tests.

However, the first series of tests does show one important point. Opening the middlings port can account for large gains in weight and iron recoveries. Higher silica concentrates can be tolerated under a regrind circuit because the high tension process also becomes more efficient. Although the Lab scale unit proves this point the acceptable level of silica would have to be determined for certain from plant-scale high tension operation.

Results from sample sets No.'s 19 - 30 (Table 11) enable a good estimate of the improvements gained from regrinding middlings. Under this series of tests all spiral splitter settings were identical on both Mill Lines # 3 and # 4 (middlin ports at a 4 setting). The regrind circuit was superior, accounting for increases in spiral weight and iron recoveries of 1.23 and 1.68 percentage points repectively, compared to the standard circuit. It is interesting to note that the spiral tailing iron assay was lower on the regrind mill for ten out of the twelve sets. The average silica assay in the spiral concentrates was very similar; the regrind mill being slightly higher (5.89% from Mill # 4 vs. 5.54% from Mill # 3).

The testing of both the standard and regrind circuits on Mill Line # 4 (Method II testing) also shows that a regrind circuit improves spiral weight and iron recoveries. With a difference in spiral concentrate silica grade of only 0.14 percentage points the regrind circuit showed weight and iron recoveries 1.33 and 2.39 points higher than the standard circuit.

4.4 LABORATORY HIGH TENSION TESTWORK:

The high tension process is most efficient when the feed material is closely sized. Testwork in the past (Wabush Report No. W-470) has shown the optimum feed size range to be -35 +150 mesh, the same as that for spiral feed. From Table 7, 73.01% of the spiral concentrate produced from the regrind circuit is in this size range compared to only 70.22% from the standard circuit. The expected improvement in the high tension process was verified through laboratory testing.

Regrinding middlings reduces the amount of silica distributed in the +35 mesh fractions of the spiral concentrate. Since high tension silica recovery is extremely high in the +35 mesh fractions (Figure 3) regrinding reduces the amount of silica reporting to the high tension concentrate. In Table 14 all three sample groups A, B and C show less +35 mesh material and less silica distributed in this size fraction in the high tension concentrate from Mill # 4.

With a more efficient high tension process it is possible to produce a satisfactory high tension concentrate from a spiral concentrate higher in silica than could be tolerated from the standard circuit. The question then arises, concerning how high the spiral silica can be increased on a regrind circuit. Theoretically, using the ratios presented in Table 13, a spiral concentrate 17% higher in silica could be produced from a regrind circuit and still maintain the same grade in high tension. However, it should be noted that this is based on the results from the laboratory unit which is more efficient than the plant circuit.

It is quite possible that, if established plantwide, the improvement in spiral weight recovery may exceed the 1.23 percentage point figure. This figure was achieved by producing spiral concentrates with very similar silica assays. As shown in Table 4 if the spiral concentrate silica is increased the reward is large gains in both weight and iron recoveries.

4.5 PLANT WIDE CONVERSION TO MIDDLINGS REGRIND

The effect of regrinding middlings on a sizer mill line (#1, 5, 6) cannot be stated for certain. It is doubtful whether the full benefits of regrinding middlings can

be achieved on a sizer mill line. Because of the inefficiencies of the sizers they tend to allow a coarser feed size structure to the spirals. This would tend to offset the benefits from regrinding middlings. In addition, the sizers, which are more sensitive than screens to increases in feed tonnage, may not be able to handle the additional tonnage from the recirculating middlings load. This would have to be determined by in-plant testing. Ideally, the sizers should be replaced by more efficient sizing screens before establishing a middling regrind circuit. However, if sizer capacity does not pose a problem the sizer lines should still be converted to regrind circuits because there will still be some improvement in spiral recoveries.

It is therefore recommended that all six mill lines at Scully Mine be converted to regrind the spiral middlings.

CONCLUSIONS & RECOMMENDATIONS:

Recirculation of spiral middlings to the mill resulted in further grinding of the coarse (+35 mesh) particles to a finer size. Regrinding middlings did not cause any limitations in mill throughput and did not have a negative effect on sizing screen efficiencies.

A reduction in the amount of +35 mesh material throughout the regrind circuit produced improvements in spiral weight and iron recoveries of 1.23 and 1.68 percentage points, respectively as compared to the standard circuit.

Middlings regrind produced spiral concentrate with less silica distributed in the +35 mesh fractions. Since high tension silica recovery is very high in these coarse fractions regrinding improved the efficiency of high tension separation. Laboratory tests showed that to produce the same product from high tension, spiral concentrate (high tension feed) from a regrind circuit could contain 17% more silica than from the standard circuit.

It is recommended that all mill lines at Scully Mine be converted to regrind spiral middlings. Although middlings regrind was not evaluated on a sizer mill line, converting the sizer lines should give some of the performance improvement achieved on a screen line.

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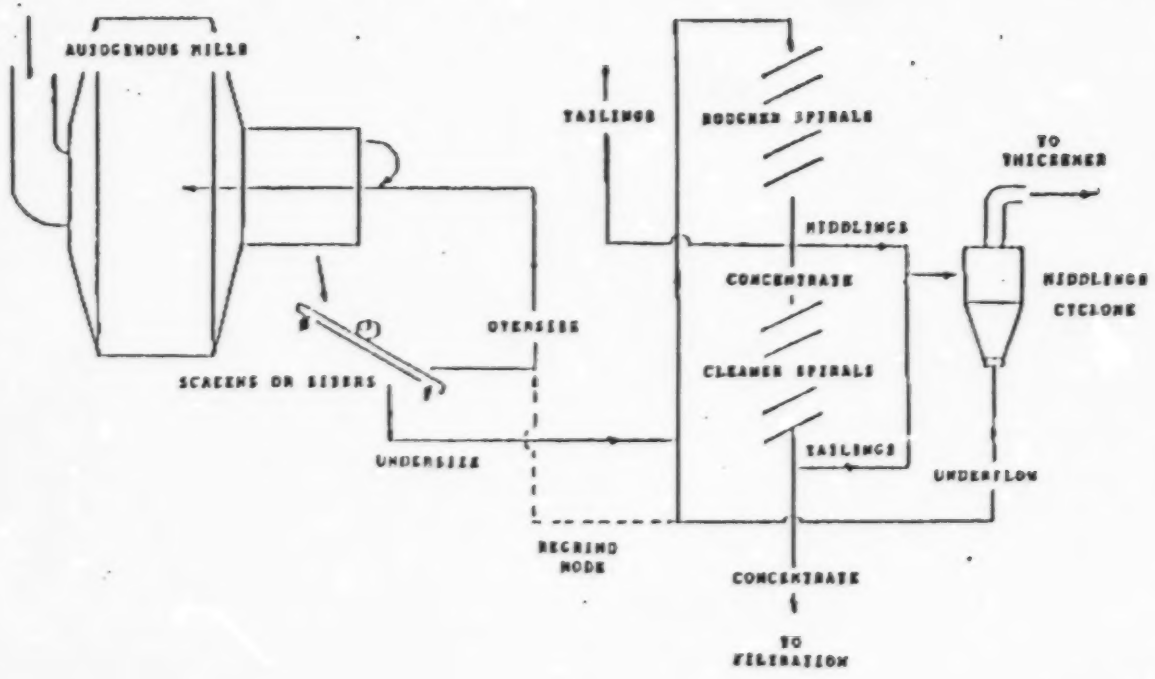

FIGURE 1 Spiral plant flowsheet at Scully Mine

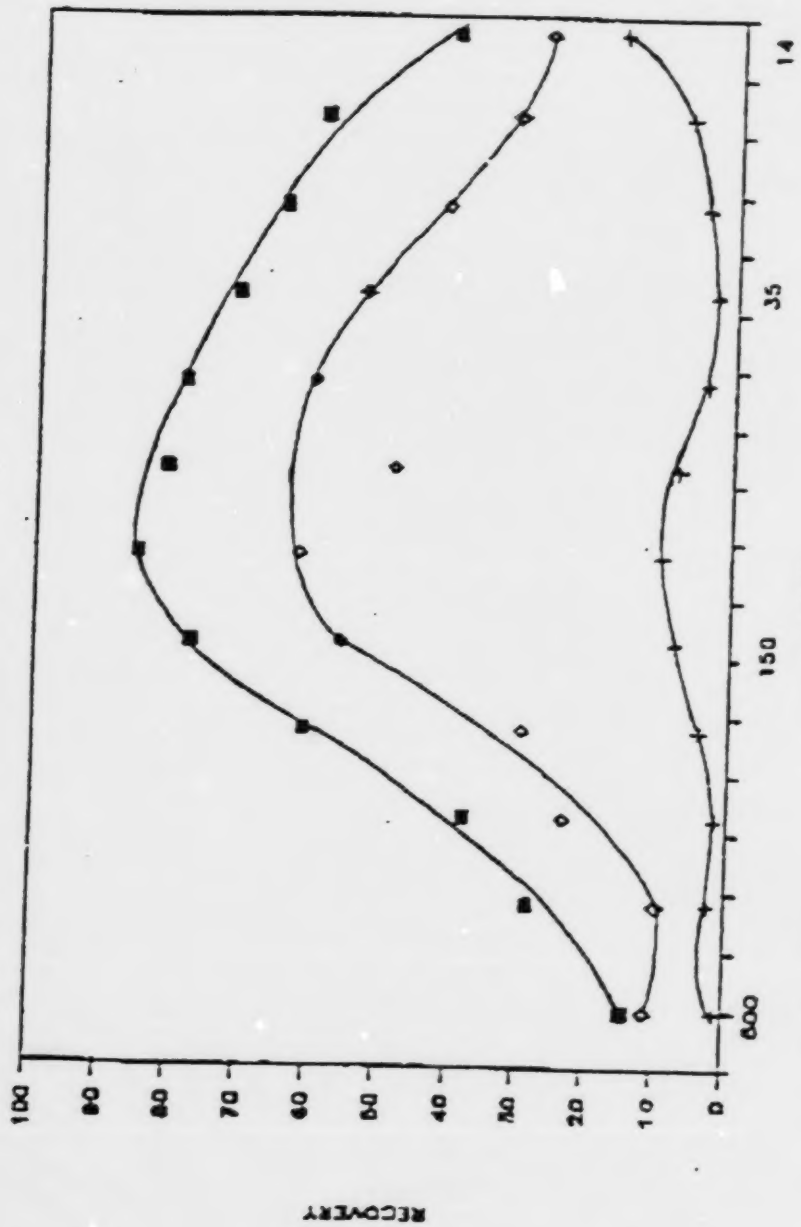

FIGURE 2 Typical Recovery Curves for the Spiral Plant at Scully Mine.

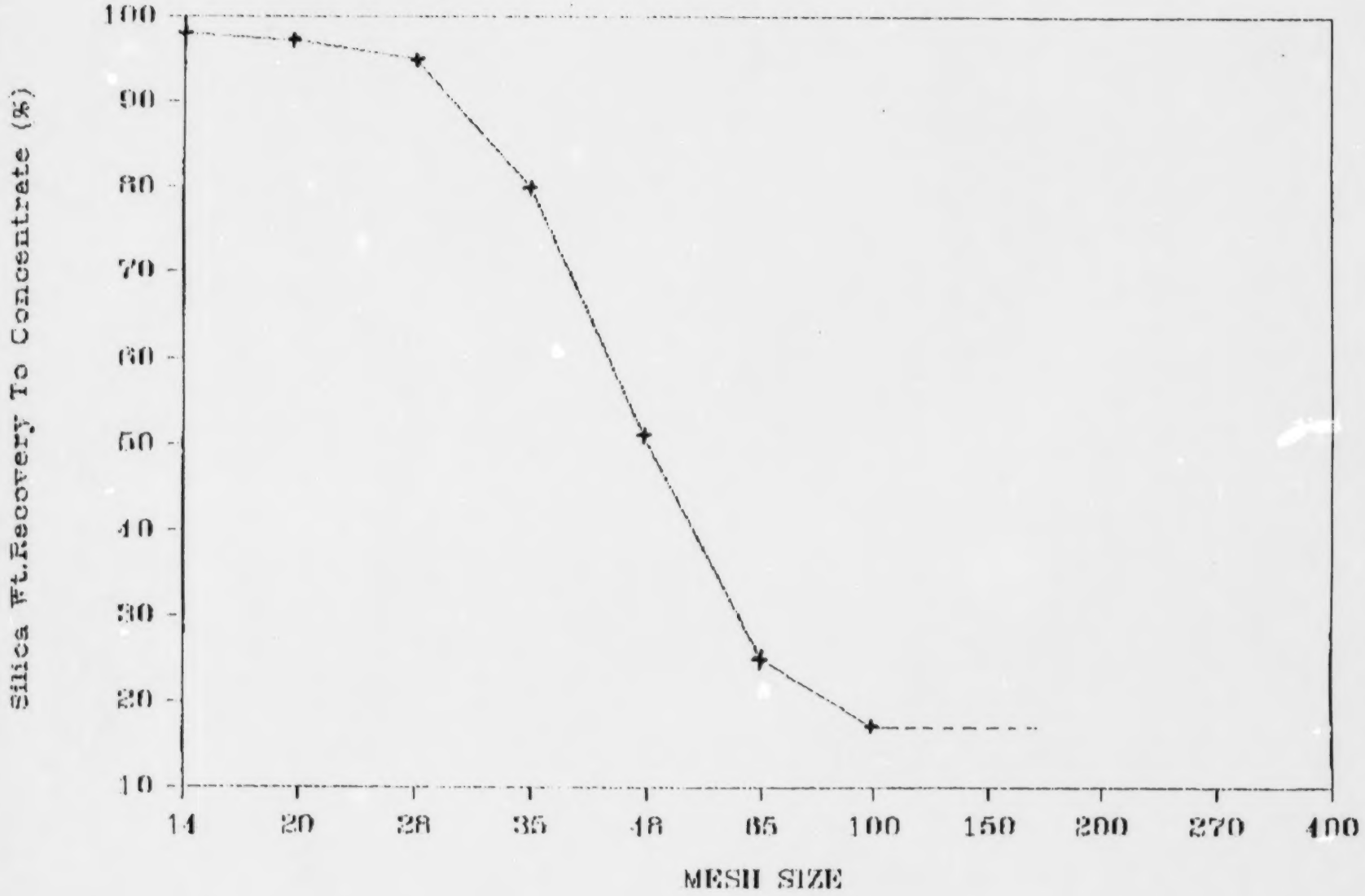

FIGURE 3 High Tension Silica Recovery by Size Fraction - (Wabush Report #W-470)

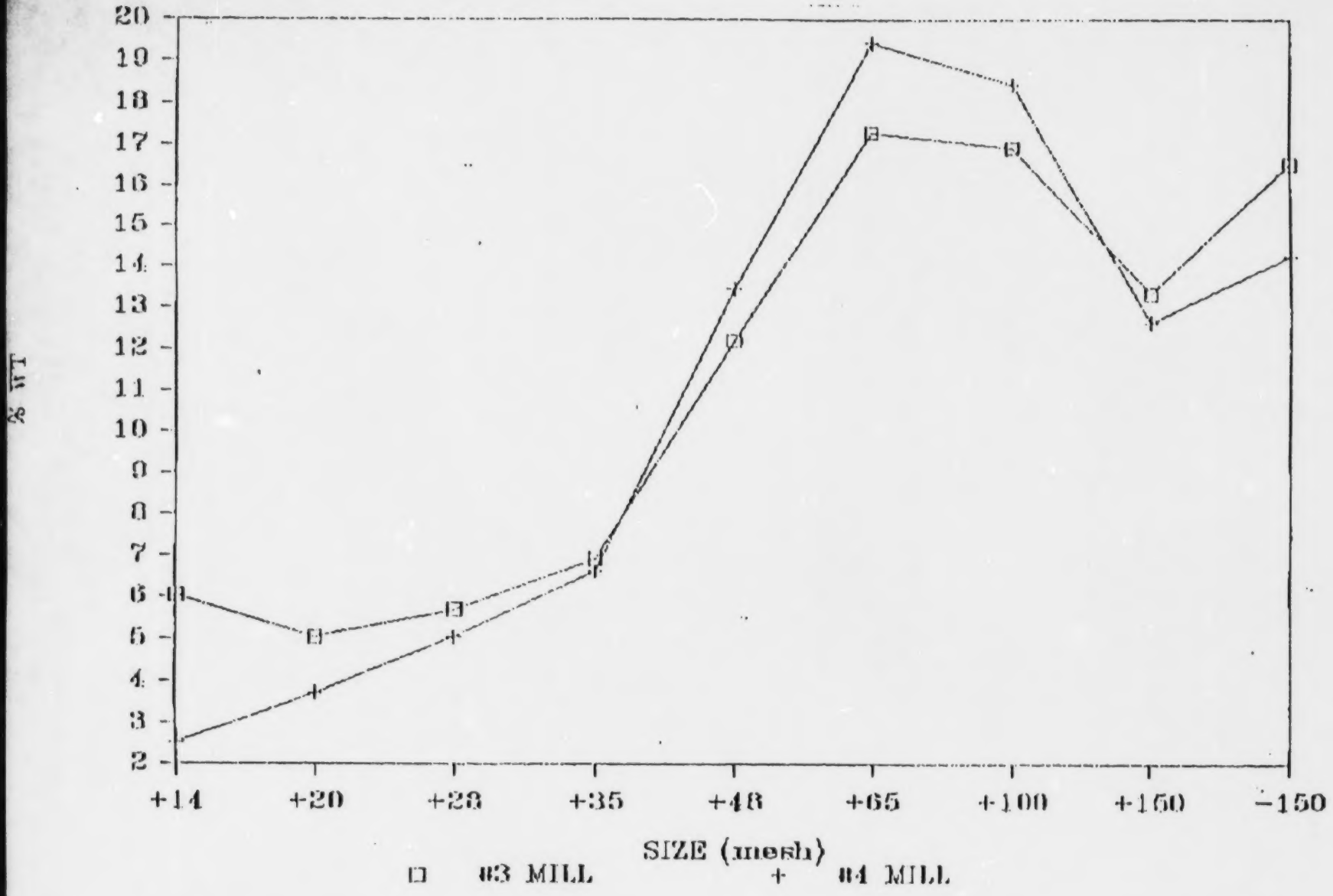

FIGURE 4 Comparison of Middlings Cyclone Underflow Size Distribution Between Mill Lines #3 and #4 (Series I).

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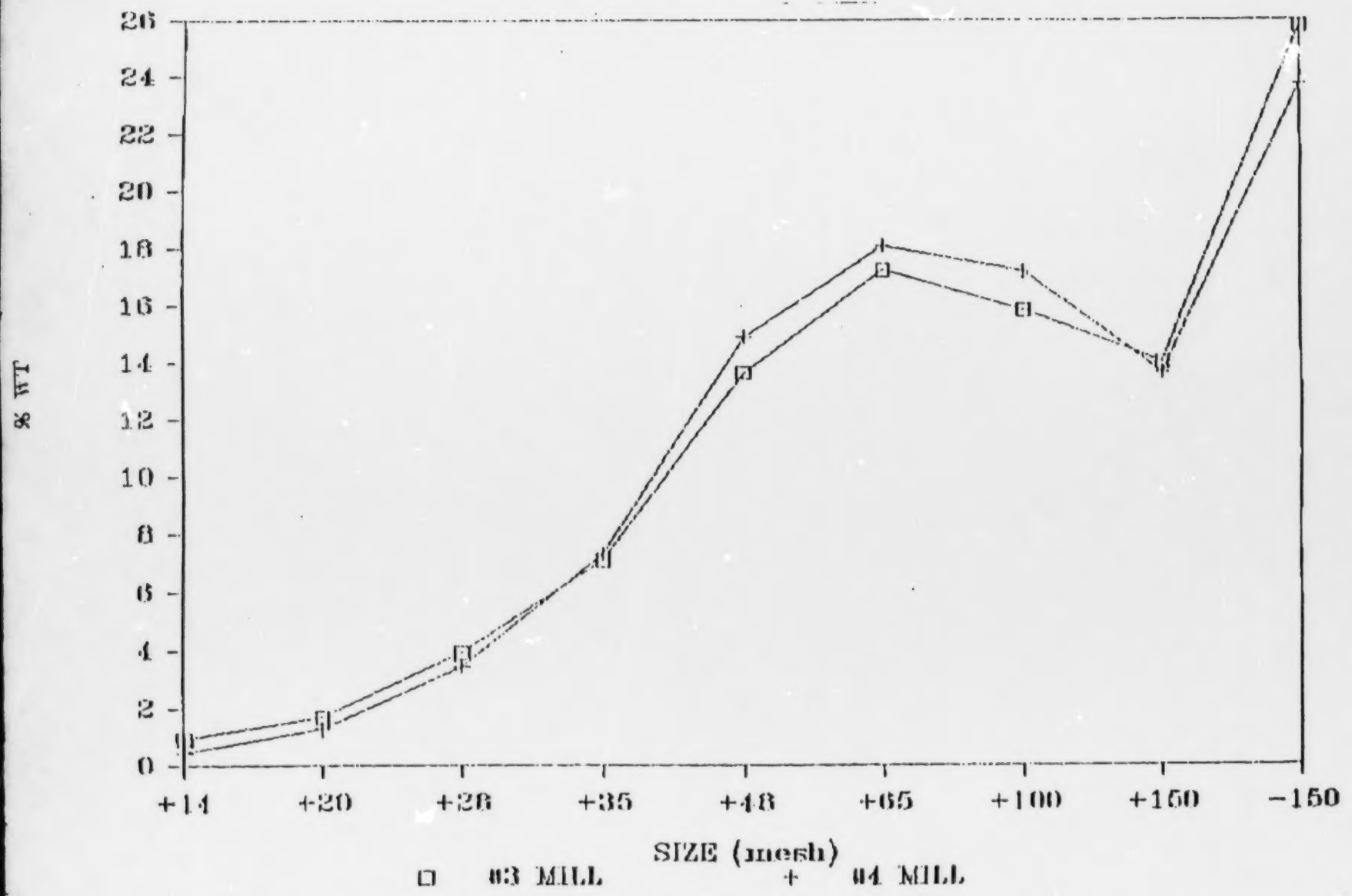

FIGURE 5 Comparison of Spiral Total Feed Size Distribution Between Mill Lines #3 and #4 (Series I).

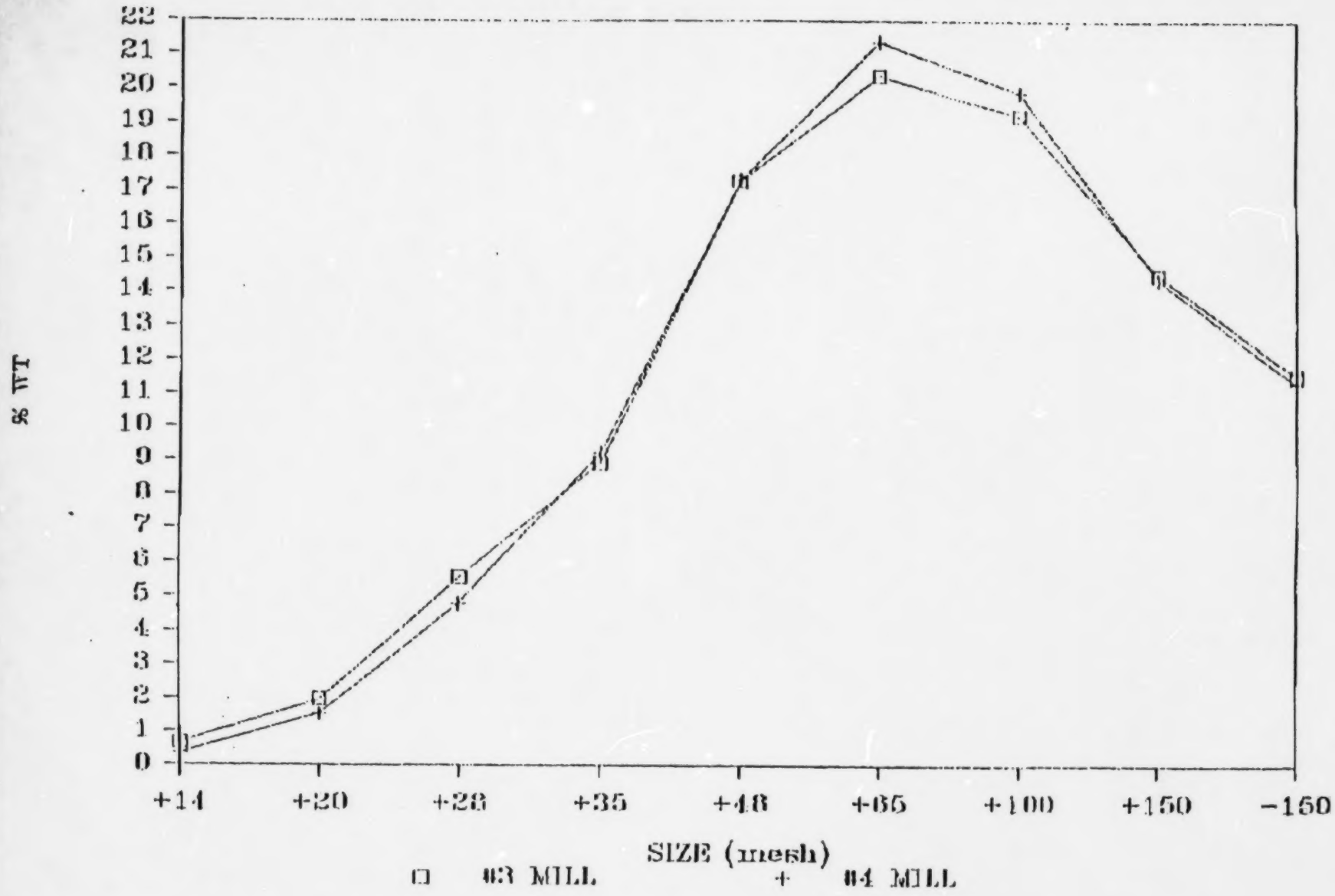

FIGURE 6 Comparison of Spiral Cleaner Concentrate Size Distribution Between Mill Lines #3 and #4 (Series 1).

TABLE 1 Comparison of Middlings Cyclone Underflow for Regrind Mill (#4) and Standard (#3) for Series I Testing -Average of 18 test sets

# 3 MILL			# 4 MILL		
Mesh Size	% Wt.	Cum. % Wt.	Mesh Size	% Wt.	Cum. % Wt.
+14	6.04	6.04	+14	2.58	2.58
+20	5.05	11.09	+20	3.91	6.48
+28	5.71	16.80	+28	5.38	11.87
+35	6.91	23.71	+35	6.94	18.81
+48	12.20	35.91	+48	14.22	33.03
+65	17.29	53.20	+65	20.34	53.38
+100	16.91	70.11	+100	19.11	72.49
+150	13.34	83.45	+150	12.99	85.48
-150	16.53	99.98	-150	14.53	100.01

TABLE 2 Comparison of Spiral Total Feed for Regrind Mill (#4) and Standard (#3) for Series I Testing -Average of 18 test sets

# 3 MILL			# 4 MILL		
Mesh Size	% Wt.	Cum. % Wt.	Mesh Size	% Wt.	Cum. % Wt.
+14	0.94	0.94	+14	0.44	0.44
+20	1.70	2.64	+20	1.30	1.74
+28	3.95	6.59	+28	3.49	5.23
+35	7.11	13.70	+35	7.33	12.56
+48	13.61	27.31	+48	14.85	27.41
+65	17.20	44.51	+65	18.06	45.47
+100	15.80	60.31	+100	17.17	62.64
+150	13.97	74.28	+150	13.60	76.24
-150	25.72	100.00	-150	23.72	99.96

TABLE 3 Comparison of Spiral Cleaner Concentrate for Regrind Mill (#4) and Standard (#3) for Series I Testing -Average of 18 test sets

# 3 MILL			# 4 MILL		
Mesh Size	% Wt.	Cum. % Wt.	Mesh Size	% Wt.	Cum. % Wt.
+14	0.66	0.66	+14	0.32	0.32
+20	1.97	2.63	+20	1.53	1.85
+28	5.56	8.19	+28	4.79	6.64
+35	8.94	17.13	+35	9.24	15.88
+48	17.28	34.41	+48	17.33	33.21
+65	20.38	54.79	+65	21.37	54.58
+100	19.20	73.99	+100	19.87	74.45
+150	14.49	88.48	+150	14.36	88.81
-150	11.53	100.01	-150	11.26	100.07

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TABLE 4 Comparison of Weight and Iron Recoveries Between Mill #3 (Standard) and Mill #4 (Middlings Regrind) for Series I Testing

			# 3 MILL							# 4 MILL						
Sample Date	Spiral New Feed		Mill LTPH	Spiral Concentrate			Spiral Tails		% Wt. Recovery	%Fe Recovery	Mill LTPH	Spiral Concentrate			Spiral Tails		% Wt. Recovery	%Fe Recovery
	%Fe	%Mn		%Fe	%SiO2	%Mn	%Fe	%Mn				%Fe	%SiO2	%Mn	%Fe	%Mn		
6-14-88	34.89	1.87	425	61.76	6.34	2.13	19.67	1.44	36.16	64.01	405	61.62	6.56	2.40	18.93	1.39	37.39	66.03
6-15-88	34.99	1.89	439	62.22	6.94	1.93	20.10	1.74	35.35	62.86	402	61.89	7.08	1.96	18.61	1.82	37.85	66.94
6-16-88	36.40	1.55	377	61.80	8.54	1.23	30.71	3.85	18.30	31.07	374	62.08	8.11	1.44	30.05	3.06	19.83	33.81
6-21-88	38.42	2.05	314	61.03	7.80	1.82	22.28	2.25	41.65	66.16	315	60.46	8.54	1.96	21.15	1.89	43.93	69.14
6-23-88	33.61	2.21	341	63.11	5.52	1.72	19.00	2.16	33.12	62.19	405	61.93	6.49	2.30	18.12	1.89	35.36	65.15
6-24-88	33.42	2.74	386	62.45	5.51	2.58	15.28	2.63	38.46	71.86	377	60.74	7.46	2.74	12.80	2.34	43.01	78.17
6-25-88	43.54	1.98	365	62.77	6.26	2.08	20.44	1.94	34.57	78.67	330	60.59	8.83	2.09	17.00	1.76	40.89	84.73
7-05-88	35.38	1.83	287	63.84	5.42	1.50	21.83	1.71	32.25	58.20	430	64.33	5.99	1.20	19.69	1.64	35.15	63.91
7-11-88	30.00	1.71	427	64.12	5.57	1.39	17.94	1.55	26.12	55.82	410	61.67	8.47	1.56	15.49	1.40	31.42	64.59
7-13-88	35.53	1.59	381	64.32	6.58	0.96	17.69	1.81	38.26	69.26	414	62.07	8.41	1.32	13.59	1.83	45.26	79.06
7-14-88	33.53	1.53	415	63.78	6.05	1.45	18.43	1.37	33.30	63.34	436	60.88	9.17	1.90	15.29	1.38	40.01	72.64
7-15-88	35.29	1.43	417	64.70	5.18	1.00	17.16	1.59	38.14	69.92	433	62.70	7.87	1.05	14.31	1.36	43.36	77.03
7-19-88	37.76	0.77	387	65.59	4.28	0.67	19.86	0.76	39.14	67.99	412	64.02	6.58	0.81	19.02	0.71	41.64	70.61
7-20-88	34.90	1.03	436	65.00	5.26	1.17	21.37	1.50	31.01	57.76	413	63.43	6.71	1.17	18.04	1.45	37.14	67.51
7-22-88	36.74	1.47	429	64.74	5.34	0.88	17.94	1.55	40.17	70.79	416	63.13	6.85	1.19	13.73	1.32	46.58	80.04
7-25-88	33.74	1.64	377	64.72	4.39	1.11	18.99	1.77	32.25	61.87	423	62.19	7.19	1.42	16.07	1.52	38.31	70.62
7-26-88	30.20	1.40	433	64.96	4.96	0.86	19.74	1.44	40.82	69.42	424	62.41	7.52	1.16	18.34	1.54	45.06	73.63
7-27-88	37.08	0.67	423	65.28	4.19	0.69	20.32	0.56	37.28	65.63	380	63.71	6.34	0.91	17.33	0.60	42.58	73.17
AVERAGE	35.75	1.63	392	63.68	5.79	1.40	19.93	1.76	35.91	63.71	400	62.21	7.45	1.59	17.64	1.61	40.26	69.82
STD. DEV.	2.82	0.50	44	1.38	1.16	0.55	3.20	0.71	7.37	9.91	33	1.17	0.96	0.56	3.87	0.55	8.13	10.79

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TABLE 5 Comparison of Middlings Cyclone Underflow Assay and Distribution By Size Fraction (Series II)

Mesh Size	# 3 MILL (Standard) Wt.%	ASSAY % Fe	% SiO2	% Mn	DISTRIBUTION % Fe	% SiO2	% Mn	# 4 MILL (Regrind) Wt.%	ASSAY % Fe	% SiO2	% Mn	DISTRIBUTION % Fe	% SiO2	% Mn
+14	5.57	48.95	11.93	8.75	7.37	1.79	12.26	2.53	47.83	14.17	8.21	3.46	0.87	5.58
+20	6.10	49.76	9.75	8.97	8.20	1.60	13.76	4.33	49.88	11.25	8.70	6.17	1.18	10.12
+28	6.90	51.02	10.37	8.03	9.52	1.93	13.95	5.83	49.93	10.94	8.55	8.31	1.55	13.38
+35	6.85	47.71	18.96	5.90	8.84	3.50	10.18	6.03	47.84	15.91	7.49	8.24	2.33	12.13
+48	11.26	38.47	33.77	4.29	11.71	10.24	12.16	12.07	35.79	37.66	4.47	12.33	11.05	14.48
+65	16.62	28.05	52.23	2.58	12.61	23.39	10.80	18.40	23.87	57.95	2.68	12.53	25.92	13.23
+100	15.39	22.19	60.82	2.00	9.23	25.22	7.75	17.50	21.60	62.65	2.27	10.79	26.65	10.66
+150	14.91	28.10	52.72	2.22	11.33	21.18	8.33	17.03	28.60	53.74	2.12	13.90	22.25	9.69
-150	16.40	47.77	25.22	2.62	21.18	11.14	10.81	16.27	52.32	20.73	2.46	24.29	8.20	10.74
Calc.Head	100.00	36.98	37.12	3.97	100.00	100.00	100.00	100.00	35.05	41.14	3.73	100.00	100.00	100.00
Assay Head		37.41	38.39	3.68					35.44	38.79	3.85			

TABLE 6 Comparison of Total Feed Assay and Distribution By Size Fraction (Series II)

Mesh Size	# 3 MILL (Standard) Wt.%	ASSAY % Fe	% SiO2	% Mn	DISTRIBUTION % Fe	% SiO2	% Mn	# 4 MILL (Regrind) Wt.%	ASSAY % Fe	% SiO2	% Mn	DISTRIBUTION % Fe	% SiO2	% Mn
+14	0.78	38.41	29.10	4.74	0.88	0.50	1.41	0.51	39.33	32.29	4.13	0.58	0.37	0.90
+20	1.38	43.04	25.53	6.01	1.74	0.79	3.17	1.31	41.96	27.24	4.44	1.60	0.81	2.52
+28	3.43	41.42	29.73	4.06	4.17	2.28	5.33	3.27	41.23	31.91	3.68	3.91	2.36	5.19
+35	5.66	35.29	41.46	2.82	5.86	5.24	6.10	5.46	37.57	39.00	2.68	5.95	4.82	6.31
+48	12.07	30.33	50.96	1.95	10.75	13.73	9.00	11.32	28.33	52.47	1.96	9.31	13.44	9.57
+65	16.81	28.46	52.99	1.77	14.04	19.88	11.37	16.72	28.55	53.79	1.76	13.85	20.35	12.69
+100	14.08	28.90	51.76	1.72	11.94	16.26	9.26	16.30	29.56	52.11	1.81	14.05	19.31	12.79
+150	17.96	31.20	48.79	1.89	16.49	19.56	12.98	15.98	36.03	43.36	1.88	16.70	15.67	12.95
-150	27.83	41.79	35.03	3.89	34.13	21.76	41.39	29.05	40.37	34.78	2.96	34.04	22.86	37.09
Calc.Head	100.00	34.07	44.80	2.62	100.00	100.00	100.00	100.00	34.46	44.20	2.32	100.00	100.00	100.00
Assay Head		34.35	44.20	2.44					33.98	45.51	2.51			

TABLE 7 Comparison of Cleaner Spiral Concentrate Assay and Distribution By Size Fraction (Series II)

Mesh Size	# 3 MILL (Standard) Wt.%	ASSAY % Fe	% SiO2	% Mn	DISTRIBUTION % Fe	% SiO2	% Mn	# 4 MILL (Regrind) Wt.%	ASSAY % Fe	% SiO2	% Mn	DISTRIBUTION % Fe	% SiO2	% Mn
+14	0.78	51.83	11.90	7.20	0.64	1.78	2.58	0.35	60.21	3.56	5.38	0.33	0.23	0.85
+20	2.17	60.27	3.55	5.12	2.07	1.47	5.09	1.94	62.80	2.81	3.90	1.92	1.00	3.38
+28	5.75	64.22	2.14	3.19	5.86	2.35	8.41	4.50	64.55	1.93	2.81	4.59	1.60	5.65
+35	9.03	65.04	2.01	2.24	9.31	3.47	9.28	8.07	65.26	1.91	2.50	8.31	2.84	9.02
+48	15.38	64.86	2.89	2.15	15.82	8.50	15.17	16.34	65.24	2.91	2.29	16.83	8.76	16.73
+65	20.12	62.40	6.27	1.98	19.92	24.13	18.28	21.24	62.95	6.14	2.13	21.11	24.02	20.23
+100	18.73	62.17	7.24	1.95	18.48	25.94	16.76	21.36	61.36	8.68	2.10	20.70	34.15	20.07
+150	15.99	61.63	7.30	1.93	15.63	22.32	14.15	14.07	63.31	5.81	2.08	14.07	15.06	13.10
-150	12.05	64.19	4.36	1.86	12.27	10.05	10.28	12.14	63.25	5.52	2.02	12.13	12.34	10.97
Calc.Head	100.00	63.04	5.23	2.18	100.00	100.00	100.00	100.00	63.32	5.43	2.24	100.00	100.00	100.00
Assay Head		63.26	5.71	2.07					63.17	5.50	2.19			

TABLE 8 Comparison of Rougher Spiral Tailing Assay and Distribution By Size Fraction (Series II)

Mesh Size	# 3 MILL (Standard) Wt.%	ASSAY % Fe	ASSAY % SiO2	ASSAY % Mn	DISTRIBUTION % Fe	DISTRIBUTION % SiO2	DISTRIBUTION % Mn	# 4 MILL (Regrind) Wt.%	ASSAY % Fe	ASSAY % SiO2	ASSAY % Mn	DISTRIBUTION % Fe	DISTRIBUTION % SiO2	DISTRIBUTION % Mn
+14	0.68	38.12	32.78	4.37	1.30	0.35	1.20	0.70	22.05	59.25	2.25	0.85	0.62	0.72
+20	1.64	31.89	42.12	4.32	2.63	1.08	2.85	1.80	23.25	53.65	2.85	2.31	1.45	2.35
+28	3.95	25.59	52.12	3.61	5.09	3.24	5.75	3.63	19.53	56.26	2.86	3.91	3.05	4.75
+35	6.45	17.67	67.25	2.40	5.73	6.81	6.23	6.87	14.73	72.88	2.02	5.57	7.48	6.34
+48	13.62	12.88	74.53	1.68	8.83	15.95	9.22	12.95	10.45	79.07	1.45	7.45	15.31	8.59
+65	17.09	10.21	79.81	1.33	8.79	21.44	9.16	15.74	8.36	83.06	1.18	7.24	19.53	8.49
+100	13.54	10.29	80.36	1.38	7.02	17.10	7.53	15.21	9.70	79.79	1.33	8.12	18.14	9.25
+150	13.02	14.61	72.51	1.80	9.57	14.83	9.44	13.03	15.20	72.99	1.72	10.90	14.21	10.25
-150	30.01	33.79	40.72	4.02	51.04	19.20	48.61	30.07	32.40	44.99	3.58	53.64	20.22	49.24
Calc.Head	100.00	19.87	63.64	2.48	100.00	100.00	100.00	100.00	18.16	66.92	2.19	100.00	100.00	100.00
Assay Head		20.40	64.76	2.37					19.55	65.33	2.32			

TABLE 9 Comparison of Rougher Spiral Middlings Assay and Distribution By Size Fraction (Series II)

Mesh Size	# 3 MILL (Standard) Wt.%	ASSAY % Fe	% SiO2	% Mn	DISTRIBUTION % Fe	% SiO2	% Mn	# 4 MILL (Regrind) Wt.%	ASSAY % Fe	% SiO2	% Mn	DISTRIBUTION % Fe	% SiO2	% Mn
+14	2.09	45.61	19.40	6.84	2.10	1.57	3.50	0.95	44.99	21.36	4.30	1.10	0.62	0.88
+20	4.32	49.22	13.07	7.70	4.70	2.19	8.17	2.79	47.29	15.05	7.65	3.39	1.28	4.57
+28	6.71	52.91	9.54	7.12	7.84	2.48	11.72	5.35	47.62	12.45	8.44	6.55	2.03	9.67
+35	7.74	54.64	9.35	6.07	9.34	2.81	11.53	8.26	49.02	14.31	7.62	10.42	3.61	13.49
+48	13.17	50.39	17.98	4.37	14.66	9.18	14.12	13.41	44.42	23.94	5.64	15.32	9.79	16.20
+65	18.15	47.15	23.48	4.12	18.90	16.51	18.34	18.24	39.09	32.81	4.93	18.33	18.24	19.25
+100	16.46	36.59	40.50	2.69	13.31	25.84	10.87	19.09	29.50	47.32	3.11	14.48	27.54	12.71
+150	14.73	36.83	40.02	2.64	11.98	22.85	9.54	14.82	31.11	45.85	3.47	11.85	20.72	11.01
-150	16.64	46.70	25.70	2.99	17.16	16.57	12.21	17.08	42.27	31.04	3.34	18.56	16.17	12.22
Calc.Head	100.00	45.27	25.80	4.08	100.00	100.00	100.00	100.00	38.90	32.80	4.67	100.00	100.00	100.00
Assay Head		44.44	28.39	3.72					40.88	32.04	4.26			

TABLE 10 Comparison of Cleaner Spiral Tailing Assay and Distribution By Size Fraction (Series II)

Mesh Size	# 3 MILL (Standard) Wt.%	ASSAY % Fe	% SiO2	% Mn	DISTRIBUTION % Fe	% SiO2	% Mn	# 4 MILL (Regrind) Wt.%	ASSAY % Fe	% SiO2	% Mn	DISTRIBUTION % Fe	% SiO2	% Mn
+14	6.05	47.51	12.29	9.95	9.73	1.56	14.47	3.80	47.97	13.07	9.42	5.55	1.15	8.42
+20	6.10	48.87	11.11	9.42	10.10	1.42	13.82	5.33	49.26	10.21	9.87	7.99	1.25	12.36
+28	6.15	48.04	12.03	8.72	10.01	1.55	12.90	5.71	50.67	9.58	9.23	8.79	1.26	12.38
+35	5.18	43.18	23.22	6.97	7.57	2.52	8.67	6.13	47.91	14.37	7.80	8.94	2.03	11.24
+48	8.26	26.60	51.32	3.95	7.43	8.86	7.84	8.86	31.49	42.31	4.63	8.49	8.64	9.64
+65	12.28	13.53	74.23	2.08	5.62	19.08	6.14	12.81	20.48	59.50	3.05	7.98	17.58	9.18
+100	12.71	12.35	76.55	1.93	5.31	20.35	5.89	15.57	14.78	72.77	2.10	7.00	26.12	7.68
+150	13.79	17.69	67.81	2.34	8.25	19.56	7.75	15.39	22.45	61.51	2.47	10.51	21.83	8.93
-150	29.47	36.07	40.72	3.18	35.98	25.11	22.52	26.40	43.27	33.10	3.25	34.75	20.15	20.16
Calc.Head	100.00	29.55	47.80	4.16	100.00	100.00	100.00	100.00	32.87	43.37	4.26	100.00	100.00	100.00
Assay Head		32.25	45.40	3.90					33.75	43.14	4.12			

TABLE II Comparison of Weight and Iron Recoveries Between Mill #3 (Standard) and Mill #4 (Middlings Regrind) for Series II Testing

	Spiral New Feed		# 3 MILL							# 4 MILL						
				Spiral Concentrate			Spiral Tails				Spiral Concentrate			Spiral Tails		
Sample Date	%Fe	%Mn	Mill LTPH	%Fe	%SiO2	%Mn	%Fe	%Mn	% Wt. Recovery	%Fe Recovery	Mill LTPH	%Fe	%SiO2	%Mn	%Fe	%Mn	% Wt. Recovery	%Fe Recovery
9-6-88	35.47	2.30	398	62.18	8.00	2.02	20.72	2.04	35.58	62.37	402	62.00	7.02	2.51	20.60	2.45	35.92	62.78
9-7-88	39.91	2.88	414	64.59	5.02	2.12	20.97	2.68	43.42	70.27	405	62.36	6.85	2.38	19.67	2.49	47.41	74.08
9-14-88	37.88	2.07	399	63.29	4.78	2.55	22.03	2.00	38.41	64.18	413	63.47	5.21	2.29	21.65	2.14	38.81	65.03
9-21-88	39.76	2.06	415	65.05	3.64	1.70	23.71	2.39	38.82	63.52	394	65.33	3.55	1.73	24.08	2.35	38.01	62.46
9-28-88	34.28	1.14	422	63.23	6.65	0.85	16.03	1.10	38.67	71.32	408	62.76	7.35	0.83	16.57	1.09	38.34	70.20
9-29-88	35.51	3.02	278	63.10	4.60	2.87	18.92	3.26	37.55	66.73	327	62.91	5.25	2.76	17.52	3.39	39.63	70.22
9-30-88	35.54	1.11	430	64.63	5.67	0.95	18.16	1.18	37.40	68.01	456	64.09	6.04	0.93	17.19	1.18	39.13	70.56
10-3-88	36.91	1.87	369	62.35	6.95	1.98	19.94	1.67	40.01	67.59	370	61.70	7.43	2.24	19.39	1.68	41.41	69.22
10-4-88	36.72	1.95	280	64.12	5.58	1.71	21.28	2.08	36.04	62.93	321	63.75	5.61	1.64	20.25	2.19	37.86	65.73
10-5-88	37.35	2.34	361	61.79	5.74	2.65	22.68	2.37	37.51	62.05	356	61.97	5.98	2.77	21.47	2.38	39.21	65.04
10-10-88	34.72	3.24	284	64.68	4.83	1.84	19.13	3.38	34.23	63.76	348	63.93	4.87	2.38	18.39	3.32	35.88	66.03
10-11-88	35.84	2.01	406	62.91	5.06	2.47	23.18	2.49	31.87	55.93	419	62.91	5.46	2.46	22.66	2.10	32.75	57.48
AVERAGE	36.66	2.17	371	63.49	5.54	1.98	20.56	2.22	37.46	64.89	385	63.10	5.89	2.08	19.95	2.23	38.69	66.57
STD. DEV.	1.82	0.66	58	1.10	1.18	0.63	2.25	0.71	2.92	4.19	41	1.06	1.14	0.65	2.29	0.70	3.53	4.53

TABLE 12 Results of Lab High Tension Tests Using Spiral Concentrate from Standard and Regrind Circuits

	# 3 MILL (Standard)									# 4 MILL (Regrind)								
Sample Group	Spiral Conc. % Fe	%SiO2	%Mn	HT Concentrate % Fe	%SiO2	%Mn	HT Tailing % Fe	% Mn	Wt. Recovery Meas.	Calc.	Fe Rec. Calc.	Spiral Conc. % Fe	%SiO2	%Mn	HT Concentrate % Fe	%SiO2	%Mn	HT Tailing % Fe	% Mn	Wt. Recovery Meas.	Calc.	Fe Rec. Calc.
A	63.49	5.54	1.98	64.75	1.85	2.14	14.84	0.52	95.01	97.48	99.41	63.17	5.89	2.08	65.07	1.65	2.24	12.04	0.42	95.46	96.42	99.32
				65.65	1.79	2.13	12.97	0.42	95.52	95.90	99.16				65.18	1.79	2.23	10.33	0.38	95.53	96.34	99.40
			Average	65.20	1.82	2.14	13.91	0.47	95.27	96.69	99.29				65.13	1.72	2.24	11.19	0.40	95.50	96.38	99.36
B	64.04	5.62	1.28	66.32	1.86	1.35	17.71	0.35	95.13	95.31	98.70	63.49	6.82	1.2	66.56	1.67	1.22	14.83	0.32	94.13	94.07	98.61
				66.71	1.75	1.37	14.63	0.31	95.3	94.87	98.83				66.36	1.75	1.23	16.76	0.34	94.3	94.21	98.47
				66.91	1.86	1.33	15.06	0.33	95.5	94.46	98.70				66.66	1.78	1.21	16.81	0.37	94.6	93.64	98.32
			Average	66.65	1.82	1.35	15.80	0.33	95.31	94.88	98.74				66.53	1.73	1.22	16.13	0.34	94.34	93.97	98.47
C	64.22	5.32	1.9	65.72	2.34	2.18	13.87	0.39	95.47	97.11	99.38	63.57	5.75	2.07	65.43	2.11	2.15	14.35	0.41	96.15	96.32	99.17
				65.71	2.28	2.22	13.53	0.4	95.29	97.14	99.40				63.57	2.21	2.19	12.82	0.38	96.48	96.21	99.24
				65.23	2.42	2.26	13.59	0.4	95.81	98.04	99.59				65.66	1.98	2.15	12.7	0.38	96.32	96.05	99.21
				65.03	2.43	1.95	13.22	0.37	95.81	98.44	99.68				66.32	1.88	1.9	13.05	0.38	96.48	94.84	98.94
			Average	65.42	2.37	2.15	13.55	0.39	95.60	97.68	99.51				65.75	2.05	2.10	13.23	0.39	96.36	95.86	99.14
D	64.49	5.73	0.71	67.66	1.49	0.74	27.55	0.44	93.96	92.10	96.62	64.07	6.28	0.69	67.31	1.45	0.74	26.98	0.38	92.44	91.97	96.62
				67.64	1.45	0.75	27.61	0.43	93.61	92.13	96.63				67.35	1.41	0.74	24.92	0.30	92.41	92.27	96.99
				67.65	1.39	0.74	28.83	0.43	92.42	91.86	96.36				67.44	1.38	0.75	25.84	0.4	92.46	91.90	96.73
				67.57	1.39	0.75	25.05	0.39	93.13	92.76	97.19				67.46	1.51	0.76	19.25	0.36	93.93	92.97	97.89
			Average	67.63	1.43	0.75	27.26	0.42	93.28	92.21	96.70				67.39	1.44	0.75	24.25	0.38	92.81	92.28	97.06

TABLE 13 Comparison of Concentrate Silica Ratios Between Standard and Regrind Circuits

Sample Group	# 3 MILL CONCENTRATES (Standard)			# 4 MILL CONCENTRATES (Regrind)		
	Spiral Concentrate % SiO2 (a)	Hi Tension Concentrate % SiO2 (b)	Silica Ratio (a/b)	Spiral Concentrate % SiO2 (a)	Hi Tension Concentrate % SiO2 (b)	Silica Ratio (a/b)
A	5.54	1.82	3.04	5.89	1.72	3.42
B	5.62	1.82	3.09	6.82	1.73	3.94
C	5.32	2.37	2.24	5.75	2.05	2.80
D	5.73	1.43	4.01	6.28	1.44	4.36
AVERAGE	5.55	1.86	3.10	6.19	1.74	3.63

$$\frac{3.63 - 3.10}{3.10} = 17\ \%$$

TABLE 14 Comparison of Screen Analyses of High Tension Concentrates from Standard and Regrind Circuits

Sample	Mesh Size	# 3 MILL (Standard) HT CONCENTRATE							# 4 MILL (Regrind) HT Concentrate						
			ASSAY			DISTRIBUTION				ASSAY			DISTRIBUTION		
		Wt.%	% Fe	% SiO2	% Mn	% Fe	% SiO2	% Mn	Wt.%	% Fe	% SiO2	% Mn	% Fe	% SiO2	% Mn
A	+35	15.95	64.19	2.14	2.93	15.74	17.92	21.54	15.17	64.56	1.99	2.78	15.10	16.29	18.65
	150	72.10	65.11	1.97	2.04	72.18	74.56	67.78	73.12	64.69	1.92	2.21	72.94	75.75	71.46
	-150	11.95	65.74	1.20	1.94	12.08	7.53	10.68	11.71	66.24	1.26	1.91	11.96	7.96	9.89
	Calc.Head	100.00	65.04	1.91	2.17	100.00	100.00	100.00	100.00	64.85	1.85	2.26	100.00	100.00	100.00
	Avg.Head*		65.20	1.82	2.14					65.13	1.72	2.24			
B	+35	19.33	65.95	2.02	1.71	19.19	22.18	22.13	19.15	66.54	1.84	1.31	19.13	20.58	19.95
	150	67.47	66.41	1.77	1.47	67.45	67.84	66.39	65.64	66.68	1.74	1.23	65.71	66.71	64.21
	-150	13.20	67.25	1.33	1.30	13.36	9.97	11.49	15.21	66.40	1.43	1.31	15.16	12.70	15.85
	Calc.Head	100.00	66.43	1.76	1.49	100.00	100.00	100.00	100.00	66.61	1.71	1.26	100.00	100.00	100.00
	Avg.Head*		66.65	1.82	1.35					66.53	1.73	1.22			
C	+35	14.82	64.11	2.67	2.80	14.65	18.37	17.38	12.44	62.58	2.40	2.60	12.01	13.52	14.08
	150	69.33	64.69	2.26	2.44	69.15	72.73	70.86	69.06	65.01	2.34	2.41	69.24	73.16	72.47
	-150	15.85	66.31	1.21	1.77	16.20	8.90	11.75	18.50	65.74	1.59	1.67	18.76	13.32	13.45
	Calc.Head	100.00	64.86	2.15	2.39	100.00	100.00	100.00	100.00	64.84	2.21	2.30	100.00	100.00	100.00
	Avg.Head*		65.42	2.37	2.15					65.75	2.05	2.10			

* Average head assays from Table 12

TABLE 15 Comparison of Weight and Iron Recoveries Between Standard and Regrind Circuits on Mill # 4

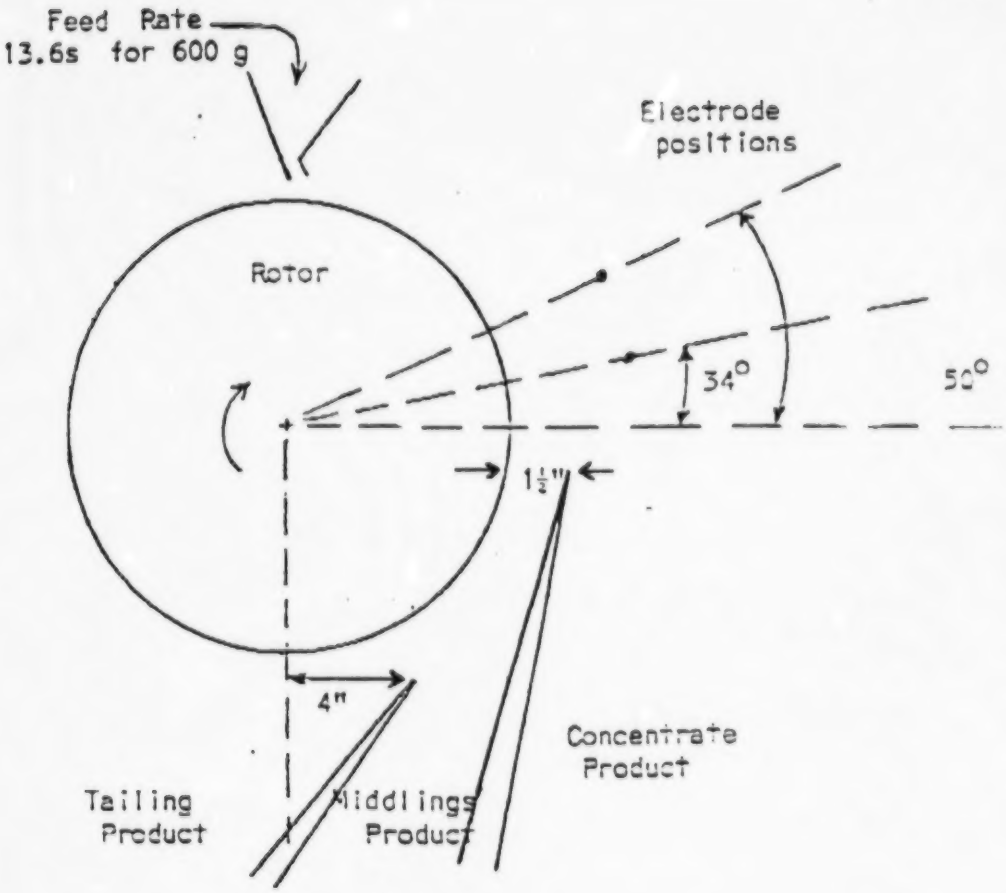
					# 4 MILL STANDARD CIRCUIT							# 4 MILL REGRIND CIRCUIT						
		Spiral New Feed			Spiral Concentrate			Spiral Tails				Spiral Concentrate			Spiral Tails			
Sample No.	Sample Date	%Fe	%Mn	Mill LTPH	%Fe	%SiO2	%Mn	%Fe	%Mn	% Wt. Recovery	%Fe Recovery	%Fe	%SiO2	%Mn	%Fe	%Mn	% Wt. Recovery	%Fe Recovery
31	10-6-88	39.95	1.71	398	63.20	5.97	1.52	20.91	2.04	44.94	71.18	63.65	6.17	1.24	20.91	2.45	44.55	70.98
32	10-19-88	39.39	2.34	414	62.63	5.85	2.66	20.79	2.00	44.46	70.68	62.72	6.26	2.24	19.97	2.00	45.43	72.33
33	10-20-88	36.75	1.64	399	62.82	6.72	1.85	22.77	2.00	34.91	59.67	63.07	6.11	1.93	21.45	2.14	36.76	63.09
34	10-21-88	36.93	0.93	415	64.18	6.72	0.90	23.17	2.39	33.55	58.31	63.73	6.02	1.39	21.72	2.35	36.21	62.98
35	10-24-88	36.03	2.29	422	63.00	5.76	2.30	21.27	1.10	35.37	61.85	64.36	4.93	2.07	20.00	1.09	36.14	64.55
36	10-26-88	37.38	1.68	278	63.55	5.67	1.63	22.81	3.26	35.76	60.80	63.00	5.94	1.94	21.18	3.39	38.74	65.29
37	10-28-88	35.84	1.38	430	62.45	6.99	1.60	20.18	1.18	37.05	64.55	62.17	7.07	1.77	20.05	1.18	37.49	65.03
	AVERAGE	37.47	1.71	394	63.13	6.24	1.80	21.70	2.00	38.00	63.86	63.24	6.07	1.80	20.75	2.09	39.33	66.25
	STD. DEV.	1.60	0.49	52	0.60	0.55	0.58	1.19	0.73	4.69	5.20	0.73	0.63	0.36	0.74	0.79	3.97	3.95

TABLE 16 Comparison of Sizing Screen Efficiencies Between Standard and Regrind Circuits on Mill # 4

	# 4 MILL STANDARD CIRCUIT				# 4 MILL REGRIND CIRCUIT			
Mesh Size	Screen Feed (f)	Screen O/S (o)	Screen U/S (u)	Screen* Efficiency	Screen Feed (f)	Screen O/S (o)	Screen U/S (u)	Screen* Efficiency
+8	5.19	21.81	0.02		5.44	23.10	0.05	
10	2.25	11.11	0.24		2.52	11.55	0.28	
14	2.30	9.73	0.62	85.49	2.29	10.81	0.56	86.29
20	3.05	9.24	1.38		3.17	10.39	1.61	
28	4.63	8.59	3.04		4.46	9.21	3.97	
35	5.99	6.64	5.44		5.70	6.27	6.28	
48	10.76	7.51	11.18		9.99	6.51	11.92	
65	15.06	7.13	17.28		14.31	6.03	17.12	
-65	50.77	18.24	60.8		52.12	16.13	58.21	
Total	100.00	100.00	100.00		100.00	100.00	100.00	

* Screen Efficiencies calculated at 14 mesh

APPENDIX I - Hi tension test conditions used to simulate normal plant operation (Held constant for all hi tension testwork)



WABUSH MINES-SCULLY MINE
PROCESS DEVELOPMENT DEPARTMENT
PROJECT #844
August 3,1988
Peter Cleyle

EVALUATION OF POLYDEX MILL SIZING SCREENS

Summary:

Polydeck Screen Corporations modular screen panels were evaluated against the plant standard Tyrethane panels in terms of metallurgical efficiency. The Polydex panels proved superior with an overall screening efficiency of 93.12% compared to 73.55% for the Tyrethane panels.

It is recommended that Polydex screens be installed on an entire mill line. Mill and spiral performance can then be evaluated under the influence of improved screening efficiency.

Introduction:

The Polydeck Screen Corporation's modular screening system (Figure 1) is reported to have several advantages over conventional screen panels including high screening efficiency, minimum maintenance costs and high operational life.

In order to test these claims, the polydex screen support frame was fitted to a Derrick vibrating deck and installed on A3 screen Mill Line #4. For comparison B3 screen mill line #4 was selected. This later deck was outfitted with a Ty-speed drive and the plant standard Tyrethane panels.

It was assumed that feed would be the same to each of these two decks because of their relative positions on the mill (Figure 2).

Procedure:

Samples were collected of screen feed, screen undersize and screen oversize on a thirty minute basis for three hours. The individual sample cuts were made into composite samples which were then subject to screen analyses to enable the calculation of screen efficiencies. This procedure was repeated on ten separate occasions.

Also, on three separate occasions, screen oversize composite samples were collected from each of the six sizing screens to afford a comparison between the polydex screen and the other five screens on Mill Line #4.

../2

(cont'd...) - 2 -

Results:

Table I compares screen efficiencies and dewatering capabilities of the Polydex screen panels and the plant standard Tyrethane panels. Clearly, the Polydex panels are superior with an average overall efficiency of 93.12% and screen oversize percent solids of 64.52%. The Tyrethane panels had an average efficiency of 73.55% and 54.73% solids in the screen oversize.

Table 2 compares the % +14 mesh material in the screen oversize for each of the six sizing screens on Mill #4. These percentages, by themselves, can be used as a measure of comparing screening efficiency. For the three sample sets taken the Polydex screen (A3) was superior to the other five sizing screens, averaging the highest percentage of +14 mesh material (48.06%) in the screen oversize.

Discussion:

The equation used to calculate efficiencies is derived from a mass balance across a screen (Appendix I). This industrial screening formula is widely used for assessing the efficiency of a screen under different conditions, operating on the same feed. Formula (4) in Appendix I was used in this report to compare the overall efficiencies of the two screens.

The chance of a particle passing through a screen aperture is proportional to the percentage of open area in the screen material, which is defined as the ratio of the net area of the apertures to the whole area of the screening surface. The Polydex screen panels have a slot opening of 1.5mm X 12mm and when fitted onto the frame the open area measures 16.5%. The plant standard Tyrethane panels have an opening of 1.6mm X 12mm and a deck open area of 13.8%. The greater open area of the Polydex screen is the reason why this screen exhibits superior metallurgical efficiency as compared to the Tyrethane screen.

The greater open area of the Polydex screen is not due to a thinner walled screen. Both the polydex and Tyrethane panels appear to be equally durable and should last the same length of time. The difference is that the Tyrethane panels require clamping hooks on the sides of each panel and rubber protective flaps across each panel on the deck. This is all dead wasted space. The modular screen panels of the Polydex system eliminate this wasted space and also produce a flat unobstructed screening surface.

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(cont'd...)

In addition to being more efficient than Tyrethane panels, the Polydex system has other advantages. The modular panels can be quickly and easily removed and replaced. In addition, if the screen surface exhibits localized wear only a few sections of screen would have to be changed out which would reduce wastage. With the plant standard Tyrethane panels, when localized wear occurs an entire screen panel must be changed out.

It should be noted that when tested, A3 deck (Polydex) was outfitted with a Derrick drive while B3 (Tyrethane) used a Ty-speed drive. Since the ty-speed drive has been reported to be superior to the Derrick drive (Process Development Project #575) it would be reasonable to assume that the Polydex system may be even more efficient if run using a ty-speed motor. This should be investigated further.

The improvement in screening efficiency with the polydex screens is substantial enough to warrant further testing of this screen. An entire mill line should be set up with polydex screens to evaluate the effect of this improved screening efficiency on mill and spiral performance.

PC/wh
08/05/88

APPENDIX I

Calculation of an efficiency equation from mass balance across a screen *

Consider a screen onto which there is a feed of F t/h, O t/h overflows from the screen and U t/h is the rate of underflow.

Let f = Fraction of material above cut point size in feed;
o = Fraction of material above cut point size in overflow;
u = Fraction of material above cut point size in undersize.

The mass balance on the screen is:

$$F = O + U$$

The mass balance of the oversize material is:

$$Ff = Oo + Uu$$

The mass balance of undersize material is:

$$F(1-f) = O(1-O) + U(1-u)$$

Hence:

$$\frac{O}{F} = \frac{f - u}{o - u}$$

$$\frac{U}{F} = \frac{o - f}{o - u}$$

The recovery of oversize material into the screen overflow:

$$= \frac{Oo}{Ff} = \frac{o(f - u)}{f(o - u)} \qquad \text{——— (1)}$$

..cont'd..

(Appendix I..cont'd..)

The corresponding recovery of undersize material in the screen underflow:

$$= \frac{C}{F}\frac{(1-u)}{(1-f)}$$

$$= \frac{(1-u)}{(1-f)}\frac{(o-f)}{(o-u)} \qquad \text{——— (2)}$$

The two relationships (1) and (2) measure the effectiveness of the screen in separating the coarse material from the underflow and the fine material from the overflow.

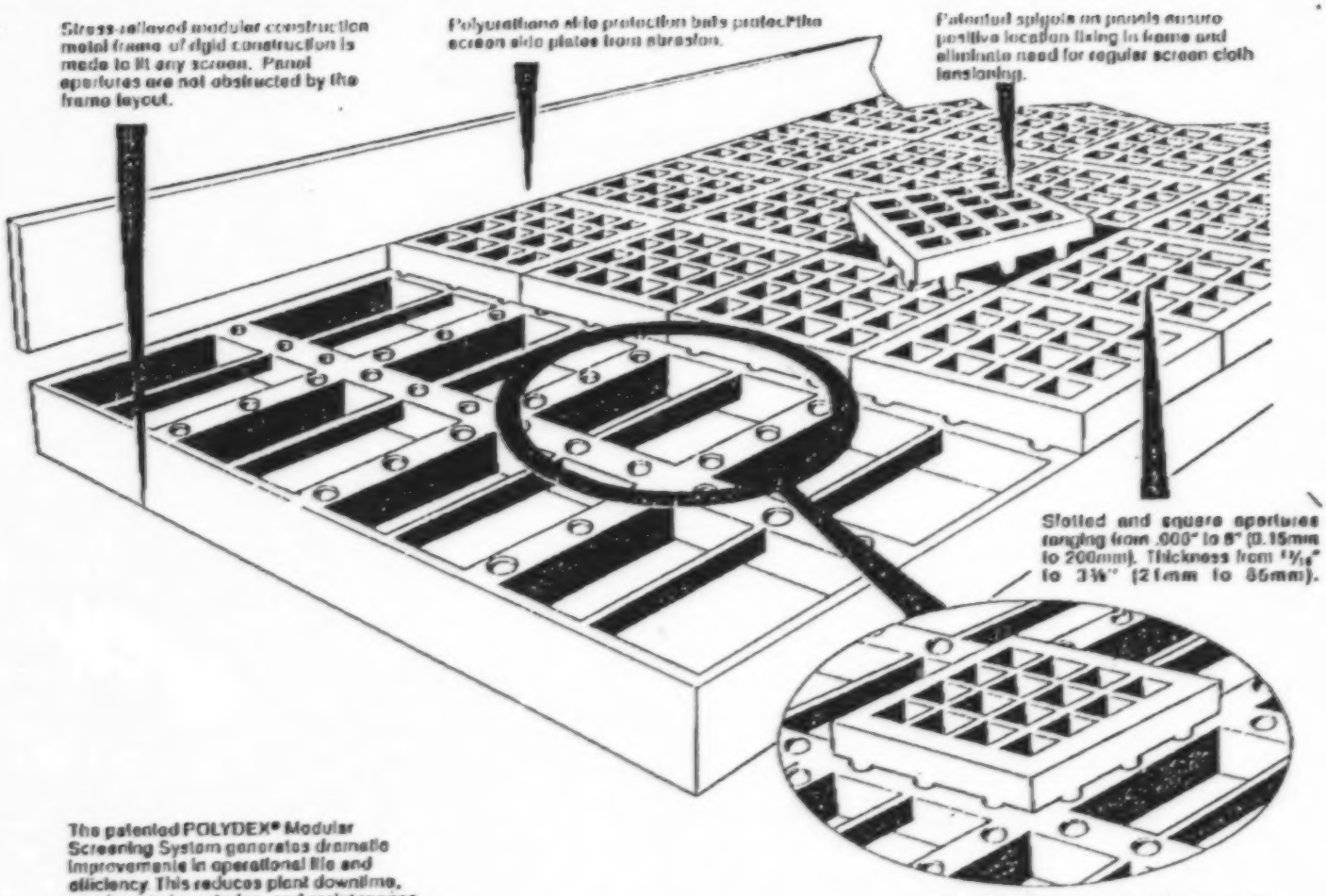
A combined effectiveness or overall efficiency E is obtained by multiplying the two equations together:

$$E = \frac{o\,(f-u)(1-u)\,(o-f)}{f\,(o-u)^2\,(1-f)} \qquad \text{——— (3)}$$

Where 'u' is very small (3) may be reduced to:

$$E = \frac{o-f}{o(1-f)} \qquad \text{——— (4)}$$

* Wills, B.A., Mineral Processing Technology, Permagon Press, Oxford,1981.


Stress-relieved modular construction metal frame of rigid construction is made to fit any screen. Panel apertures are not obstructed by the frame layout.
Polyurethane slide protection bars protect the screen side plates from abrasion.
Patented spigots on panels ensure positive location fixing to frame and eliminate need for regular screen cloth tensioning.
Slotted and square apertures ranging from .008" to 8" (0.15mm to 200mm). Thickness from 1/16" to 3 3/8" (21mm to 85mm).

The patented POLYDEX® Modular Screening System generates dramatic improvements in operational life and efficiency. This reduces plant downtime, repair parts inventories, and maintenance costs. POLYDEX® screen panels are formulated with a special abrasion resistant polyurethane with the apertures and thickness matched to the screen application. The specially designed, stress-relieved frame provides an unobstructed support for the panel.

The POLYDEX® system of modular screening panels permits individual panels to be removed or replaced in minutes by unskilled labor. The system ensures efficiency, minimum maintenance and high operational life.

FIGURE I

THE POLYDECK SCREEN CORPORATIONS MODULAR SCREENING SYSTEM

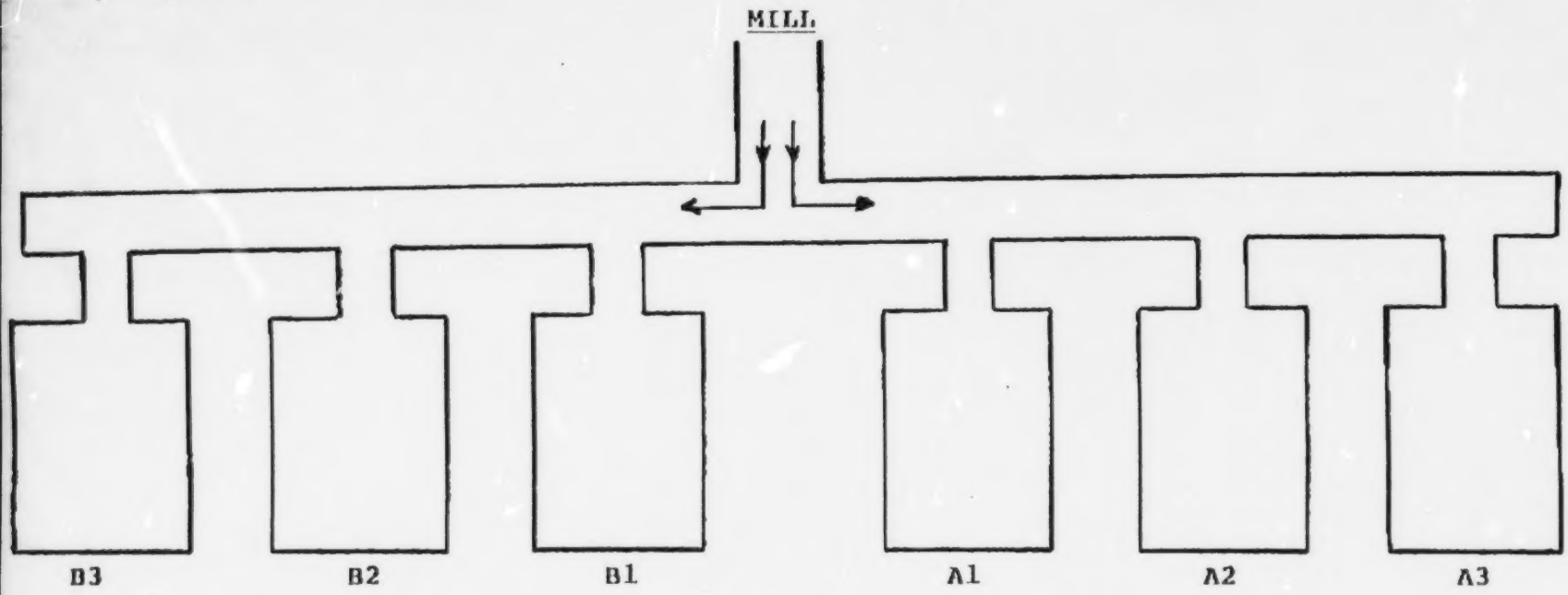


FIGURE 2

DISTRIBUTION OF SCREEN FEED

TABLE 2 OVERSIZE COMPARISON BETWEEN ALL SCREENS ON MILL 4

% +14 MESH In SCREEN OVERSIZE

SAMPLE	A1	A2	A3	B1	B2	B3
1	29.35	29.07	40.53	14.52	38.15	23.26
2	38.94	30.02	40.34	32.06	34.37	20.05
3	43.04	49.45	55.3	44.39	42.25	-
AVERAGE	37.11	36.18	48.06	30.32	38.26	21.66
ST.DEV.	5.74	9.39	6.03	12.26	3.22	1.61

TABLE 1 COMPARISON BETWEEN POLYDEX (A3) AND TYRETHANE (B3) SCRREEN PANELS

	A3 SCREEN					B3 SCREEN			
SAMPLE	o	f	SCREEN O/S % SOLIDS	EFFICIENCY (%)	SAMPLE	o	f	SCREEN O/S % SOLIDS	EFFICIENCY (%)
1	53.30	8.53	67.78	91.83	1	26.15	9.18	52.75	71.45
2	49.17	5.16	70.34	94.39	2	21.19	7.08	58.34	71.66
3	53.00	4.90	65.09	95.43	3	22.85	7.20	59.65	73.80
4	42.46	5.47	66.85	92.16	4	23.75	8.40	55.74	70.56
5	48.45	7.15	56.13	91.81	5	32.38	8.93	48.41	79.52
6	53.49	6.48	65.31	93.98	6	30.39	11.88	57.47	69.12
7	42.51	6.38	66.06	90.78	7	28.53	9.90	57.45	72.47
8	42.45	5.70	59.28	92.75	8	24.50	8.88	47.79	69.97
9	43.79	4.15	62.39	94.44	9	21.57	7.15	51.67	72.00
10	42.25	4.48	65.95	93.59	10	23.04	4.32	58.01	84.92
AVERAGE	47.09	5.84	64.52	93.12		25.43	8.29	54.73	73.55
ST. DEV.	4.68	1.26	3.97	1.40		3.63	1.92	4.07	4.67

o = % +14 Mesh in screen oversize
f = % +14 Mesh in screen feed

WABUSH MINES
SCULLY MINE

PROCESS DEVELOPMENT DEPARTMENT
PROJECT #889
July 24th, 1989
P.Cleyle

EFFECT OF 4MM TROMMEL SCREENS AND MILL CLEANUP WATER ON SIZING SCREEN PERFORMANCE:

Summary:

A complete set of test rubber trommel screens with 4mm slot openings were installed on Mill #4 and compared with the plant standard 5mm panels on Mill #3. During the test period the sizing screens on Mill #4 had an average efficiency of 92.8% compared to 82.3% on Mill #3. This improvement on Mill #4 was attributed to a combination of the 4mm trommel and more effective sizing screens on Mill #4. No operational problems or reduction in mill throughput was caused by the 4mm trommel when regrinding spiral middlings.

The effect of mill clean-up water on screen performance was investigated on Mill #4. By removing clean-up water from the mill, trommel screen efficiency increased from 76% to 78% and sizing screen efficiency improved from 90.7% to 96.5%.

It is recommended that a 4mm trommel made from urethane be tested. If wear life is acceptable and if screen performance is consistent with the rubber screens tested under the present study then the plant standard trommel should be converted to 4mm slot size. Mill basement clean-up water must be removed from the mill circuit before future testing of finer sizing screens and mill density control is possible.

INTRODUCTION:

Optimum spiral circuit performance is achieved when spiral feed material is closely sized in the -35+150 mesh range. However, presently at Wabush Mines the spiral feed size structure contains a considerable amount of +35 mesh material, as shown in Table I (Sizing Screen Undersize). The plant standard slot opening on the mill sizing screens is 1.6mm. Reducing the slot opening of these sizing screens would reduce the top size of the spiral feed material which should subsequently produce better spiral circuit performance.

Under funding from Phase III of the 1986 Mineral Development Agreement (MDA), a two-step program for the testing of finer screening was devised:

- 1) Testing of a finer slot opening on the mill trommel screens (present plant standard is 5mm);

- 2) Testing of a finer slot opening on the mill sizing screens (present plant standard is 1.6mm).

With a finer sizing screen comes an expected loss in screening efficiency. A finer trommel will reduce the sizing screen loading and should help counteract this loss.

This report presents the results from the first part of this two-step program - the testing of finer trommel screens. A 4mm slot size was selected for the test panels. Previous testing of 3mm panels (Process Development Report #700 - 1985 Fine Grind Test) indicated that this size was too fine as it caused problems with mill throughput. A complete set of test rubber panels with 4mm slots were installed on Mill Line #4 and were evaluated against the plant standard 5mm urethane panels on Mill #3.

It is important to note that the sizing screens on Mill #3 and #4 are slightly different. The screens on Mill #3 were the standard Tyler panels with 1.6mm slot openings with Derrick drives. On Mill #4 the screens were 1.5mm Polydec panels with Tyler screen drives which were previously installed for testing.

MILL CLEAN-UP WATER:

Clean-up water from the mill basement is pumped back into the mill, being added at the mill feed chute. The amount of clean-up water added to each mill is more than would normally be added at the feed conveyor beltwash hopper. This excess water which eventually becomes screen feed causes a decline in sizing screen efficiency. To help quantify this a comparison of sizing screen efficiency was conducted on Mill Line #4 with and without mill clean-up water on the mill.

PROCEDURE:

Samples of trommel screen oversize, sizing screen feed, sizing screen oversize and sizing screen undersize were collected on an hourly basis and made into four hour composites. The composite samples were filtered and dried for % solids determination and the solids subject to sieve analysis.

When comparing the 4mm vs 5mm trommel (Mill #3 vs Mill #4) ten sets of the above samples were collected. During this testing both Mill #3 and #4 were set up so that the spiral middlings was recirculated as rougher spiral feed.

To compare the effect of mill clean-up water on sizing screen efficiency, samples were collected from Mill #4 only - five sample sets with the clean-up water to the mill and five sample sets with the clean-up water to a dewatering cyclone. This cyclone was installed on test over #4 mill feed chute and effectively dewaters the cleanup material, returning only solids to the mill. The cyclone overflow reports to the tailing thickener. During this testing Mill #4 was configurated to regrind spiral middlings (spiral middlings returned to the mill for regrinding via the recirculating pump).

3.0 RESULTS & DISCUSSION:

3.1 4mm vs 5mm Trommel:

The size analysis data from the trommel and sizing screen samples collected from Mills #3 and #4 are presented in Table I and Figures 1-4. The data presented are averages for the ten sample sets collected.

All four samples from Mill #4 show a finer size distribution compared to Mill #3 (Table I). This result shows up as a downward shift in the cummulative weight percent retained curves for the samples from Mill #4 (Figures 1-4).

Using percent greater than slot size in the trommel oversize as criteria for comparing trommel screen efficiency the 5mm panels were found to have an average efficiency of 82%, compared to 77% for the 4mm panels. (Figure I). Although a lower efficiency is expected with a finer slot size this difference between the 4mm and 5mm panels can be considered minimal.

The main objective with a finer trommel is to reduce sizing screen loading thereby improving sizing screen efficiency. Using Equation (4) from Appendix I and the screen product size information the overall efficiency of the screens on mill line #3 was determined to be 82.3% compared to 92.8% on mill line #4.

The higher sizing screen efficiency on Mill #4 cannot be attributed solely to the smaller trommel screen opening. The polydec sizing screens themselves have been shown to be more efficient than the plant standard Tyler panel/Derrick drive arrangement (Process Development Report #844). However, although it cannot be quantified the smaller trommel most certainly has contributed to the improved sizing efficiency shown on Mill #4. Because they remove some of the load from the sizing screens the finer trommel screens will become a more important factor when a finer sizing screen slot size is tested.

During the test period no operational problems were experienced with the 4mm trommel. The finer trommel posed no limitations on mill throughput as both mill lines #3 and #4 averaged approximately the same tonnage (422 LTPH from Mill #3 and 415 LTPH from Mill #4). Percent solids in the trommel oversize averaged 92.4% indicating dewatering capacity was not a problem.

An added benefit of the 4mm trommel should be a reduction in wear rate of the mill recirculating pump due to the finer size structure of the screen oversize which reports to this pump. The potential savings can be quantified once more operating experience with the 4mm trommel is gained.

A complete set of 4mm trommel panels made from urethane should be obtained for further testing. The rubber panels used for this test had to be removed after only 1600 hours due to excessive wear. Compared to rubber, urethane is a better wear material and has also been shown to give better screening efficiency due to its superior blinding resistance (Process Development Report #690).

3.2 Effect of Mill Clean-Up Water On Screening Performance:

The size analyses of the trommel and sizing screen samples collected from Mill #4, with and without mill clean-up water being added, are presented in Table 2 and Figures 6 - 10. The data presented are average results for the test period. The introduction of clean-up water to the milling circuit appears to have a negative effect on screen performance. From Table 2, the % solids of the trommel oversize, screen feed, screen oversize and screen undersize samples are all higher when the clean-up water is removed from Mill #4.

A comparison of sizing screen efficiencies reveals the following; with clean-up water to the mill the efficiency averaged 90.7% and when the water was removed the efficiency increased to 96.5% (Table 3). Trommel screen efficiency increased from 76% to 78% when the clean-up water was diverted to the dewatering cyclone (Figure 5).

It appears the sizing screens cannot effectively dewater the large volume of clean-up water. As a result, more water than normal reports to screen oversize, carrying with it more fine particles. This is supported by Figure 7, which shows a shift in the screen oversize to a finer size structure when clean-up water is being added to the mill.

Clearly, the practise of direct addition of clean-up water to the mill circuit should be avoided. Because of the negative effect on screen performance no further reduction in sizing screen slot size should be considered until this water has been eliminated from the circuit.

(cont'd...) - 5 -

It is also imperative that the clean-up water is eliminated from the circuit to gain the most benefit from future process improvement projects such as mill grind control. This project will involve computer control of mill variables to maintain optimum spiral feed density. If clean-up water was added to the mill the mill density would be uncontrollable. Eliminating the clean-up water would enable the desired control through water adjustment at the beltwash hopper.

LIST OF ATTACHMENTS:

Appendix I - Calculation of an Efficiency Equation from Mass Balance Across a Screen.

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TABLE I COMPARISON OF SIZE ANALYSES OF GRINDING CIRCUIT SAMPLES FROM MILL #3 (5 mm Trommel) AND MILL #4 (4 mm Trommel)

	MESH	SCREEN OPENING.IN	TROMMEL OVERSIZE WT. %	TROMMEL OVERSIZE CUM.WT.%	SCREEN FEED WT. %	SCREEN FEED CUM.WT.%	SCREEN OVERSIZE WT. %	SCREEN OVERSIZE CUM.WT.%	SCREEN UNDERSIZE WT. %	SCREEN UNDERSIZE CUM.WT.%
	+3	0.263	65.70							
	+4	0.185	18.90	84.60	0.50		1.80		0.00	
	+6	0.131	6.10	90.70	2.00	2.50	8.20	10.00	0.00	0.00
	+8	0.093	2.10	92.80	3.00	5.50	11.60	21.60	0.00	0.00
	+10	0.065	0.70	93.50	2.90	8.40	10.90	32.50	0.10	0.10
MILL #3	+14	0.046	0.40	93.90	3.30	11.70	10.90	43.40	0.30	0.40
	+20	0.0328	0.30	94.20	3.80	15.50	10.50	53.90	0.90	1.30
	+28	0.0232	0.30	94.50	4.50	20.00	7.70	61.60	2.10	3.40
	+35	0.0164	0.50	95.00	7.30	27.30	7.60	69.20	5.40	8.80
	+48	0.0116	0.80	95.80	11.20	38.50	8.00	77.20	10.90	19.70
	-48/+65	0.0082	4.20	100.00	14.30	52.80	6.60	83.80	16.60	36.30
	-65	0			47.20	100.00	16.20	100.00	63.70	100.00
	SAMPLE % SOLIDS		95.1		55.8		71.5		45.5	
	AVERAGE MILL NEW FEED TONNAGE = 422 LT/HR.									
	+3	0.263	53.10							
	+4	0.185	16.40	69.50	0.00		0.00		0.00	
	+6	0.131	13.70	83.20	0.40	0.40	2.00	2.00	0.00	0.00
	+8	0.093	6.30	89.50	1.60	2.00	10.90	12.90	0.00	0.00
	+10	0.065	2.00	91.50	2.10	4.10	13.80	26.70	0.10	0.10
MILL #4	+14	0.046	0.90	92.40	2.40	6.50	11.10	37.80	0.40	0.50
	+20	0.0328	0.50	92.90	2.50	9.00	7.10	44.90	1.20	1.70
	+28	0.0232	0.30	93.20	3.30	12.30	5.90	50.80	2.10	3.80
	+35	0.0164	0.50	93.70	6.20	18.50	7.50	58.30	4.90	8.70
	+48	0.0116	0.80	94.50	11.10	29.60	8.80	67.10	9.70	18.40
	-48/+65	0.0082	5.50	100.00	15.50	45.10	8.90	76.00	15.70	34.10
	-65	0			54.90	100.00	24.00	100.00	65.90	100.00
	SAMPLE % SOLIDS		92.4		51.3		67.2		41.6	
	AVERAGE MILL NEW FEED TONNAGE = 415 LT/HR.									

WALKER MINES
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TABLE 2 SIZE ANALYSES COMPARISON OF GRINDING CIRCUIT SAMPLES FROM MILL #4 (MIDDLINGS REGRIND CIRCUIT) WITH CLEANUP WATER TO MILL AND WITH CLEANUP WATER TO CYCLONE

	MESH	SCREEN OPENING.I	TROMMEL OVERSIZE WT. %	TROMMEL OVERSIZE CUM.WT.%	SCREEN FEED WT. %	SCREEN FEED CUM.WT.%	SCREEN OVERSIZE WT. %	SCREEN OVERSIZE CUM.WT.%	SCREEN UNDERSIZE WT. %	SCREEN UNDERSIZE CUM.WT.%
	+3	0.263	49.50							
	+4	0.185	18.80	68.30	0.00		0.00		0.00	
	+6	0.131	14.20	82.50	0.30	0.30	2.30	2.30	0.00	0.00
MILL #4	+8	0.093	5.80	88.30	1.30	1.60	11.30	13.60	0.00	0.00
CLEANUP	+10	0.065	1.80	90.10	1.80	3.40	13.20	26.80	0.00	0.00
WATER	+14	0.046	0.80	90.90	2.10	5.50	12.20	39.00	0.40	0.40
TO MILL	+20	0.0328	0.40	91.30	2.40	7.90	7.80	46.80	1.00	1.40
	+28	0.0232	0.40	91.70	3.30	11.20	6.50	53.30	2.10	3.50
	+35	0.0164	0.70	92.40	6.80	18.00	8.60	61.90	5.40	8.90
	+48	0.0116	1.10	93.50	12.40	30.40	9.90	71.80	11.30	20.20
	-48/+65	0.0082	6.50	100.00	15.90	46.30	9,00	80.80	16.40	36.60
	-65	0			53.70	100.00	19.20	100.00	63.40	100.00
	SAMPLE % SOLIDS		89.4		43.5		69.2		39.4	

AVERAGE MILL NEW FEED TONNAGE = 412 LT/HR.

	+3	0.263	52.20							
	+4	0.185	18.70	70.90	0.00		0.00		0.00	
	+6	0.131	13.20	84.10	0.20	0.20	4.90	4.90	0.00	0.00
MILL #4	+8	0.093	5.00	89.10	0.90	1.10	18.40	23.30	0.00	0.00
CLEANUP	+10	0.065	1.50	90.60	1.40	2.50	18.90	42.20	0.00	0.00
WATER TO	+14	0.046	0.80	91.40	1.90	4.40	15.10	57.30	0.30	0.30
CYCLONE	+20	0.0328	0.50	91.90	2.60	7.00	8.70	66.00	1.00	1.30
	+28	0.0232	0.50	92.40	3.90	10.90	6.60	72.60	2.20	3.50
	+35	0.0164	0.80	93.20	8.10	19.00	6.90	79.50	6.30	9.80
	+48	0.0116	1.10	94.30	13.70	32.70	6.40	85.90	12.60	22.40
	-48/+65	0.0082	5.70	100.00	16.40	49.10	4.90	90.80	17.10	39.50
	-65	0			50.90	100.00	9.20	100.00	60.50	100.00
	SAMPLE % SOLIDS		93.4		52.1		75.5		43.0	

AVERAGE MILL NEW FEED TONNAGE = 392 LT/HR.

TABLE 3 SUMMARY OF TROMMEL AND SIZING SCREEN EFFICIENCIES

		TROMMEL SCREEN EFFICIENCY(%)*	CUMULATIVE PERCENT ABOVE SLOT SIZE		SIZING SCREEN EFFICIENCY(%)**
			Screen Feed	Screen O/S	
n vs 5mm mmel Test	Mill # 3 (5mm)	82	8.0	33.0	82.3
	Mill # 4 (4mm)	77	3.0	30.0	92.8
l # 4 an-up Water est	Mill # 4 (without water)	78	3.0	47.0	96.5
	Mill # 4 (with water)	76	4.0	31.0	90.7

* % above slot size -Figures - 1,5

** from Eqn.4 Appendix I

TROMMEL SCREEN OVERSIZE

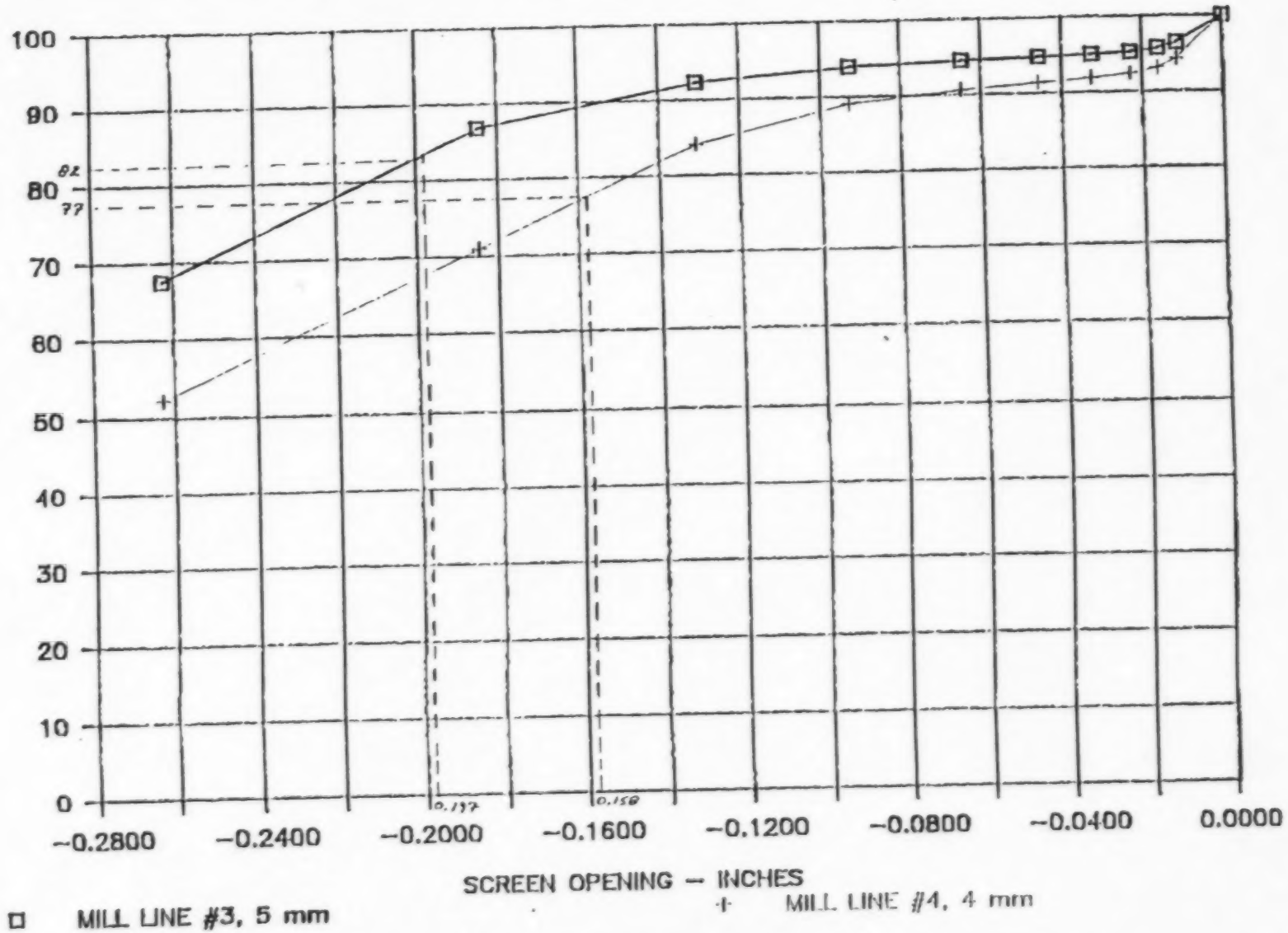

FIGURE I: SIZE STRUCTURE COMPARISON OF TROMMEL OVERSIZE BETWEEN MILL #3 (5MM TROMMEL) AND MILL #4 (4MM TROMMEL).

ATTACHMENT X
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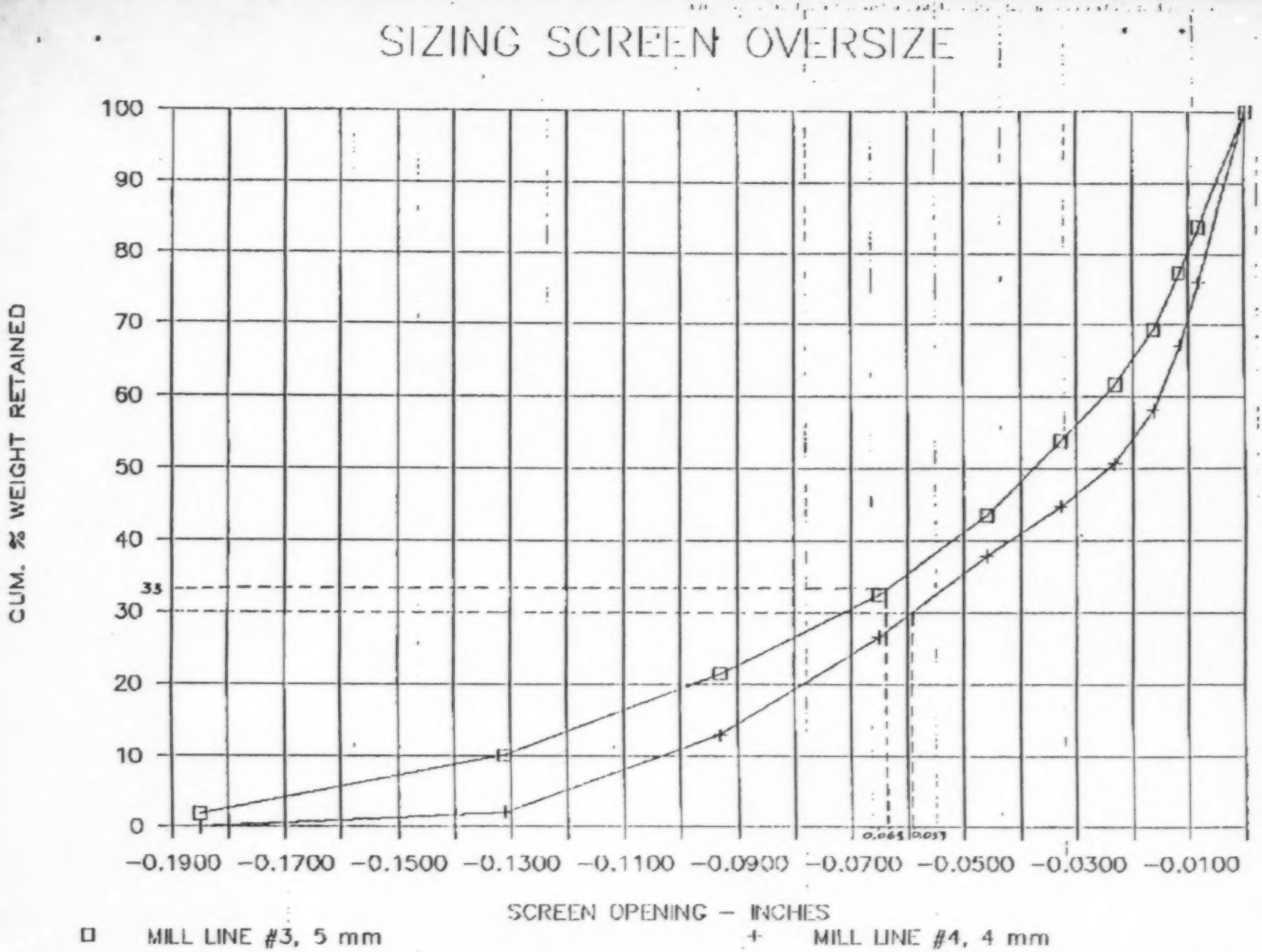

FIGURE 11: SIZE STRUCTURE COMPARISON OF SIZING SCREEN OVERSIZE BETWEEN MILL #3 (5MM TROMMEL) AND MILL #4 (4MM TROMMEL).

SIZING SCREEN FEED

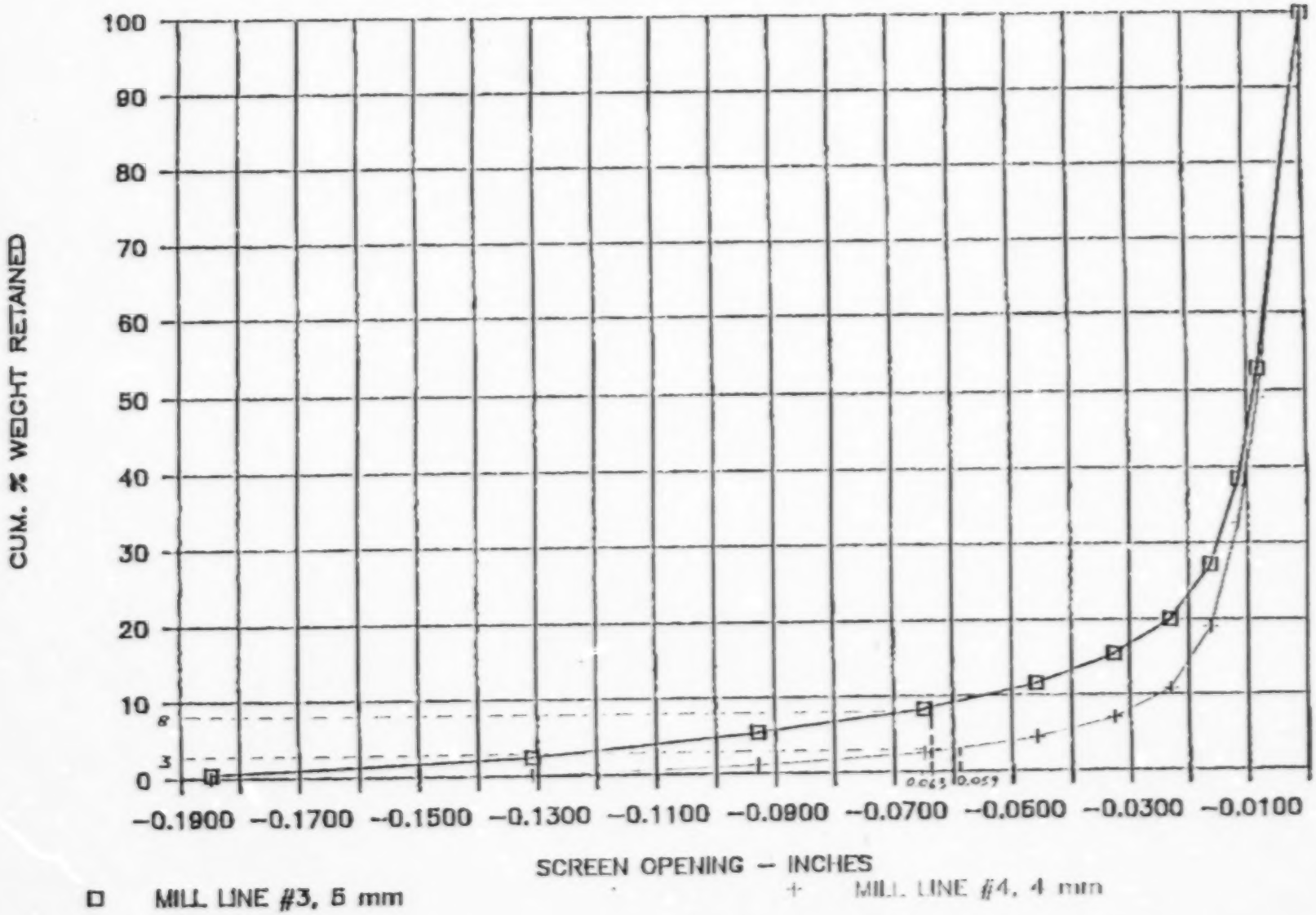

FIGURE III: SIZE STRUCTURE COMPARISON OF SIZING SCREEN FEED BETWEEN MILL #3 (5MM TROMMEL) AND MILL #4 (4MM TROMMEL).

SIZING SCREEN UNDERSIZE

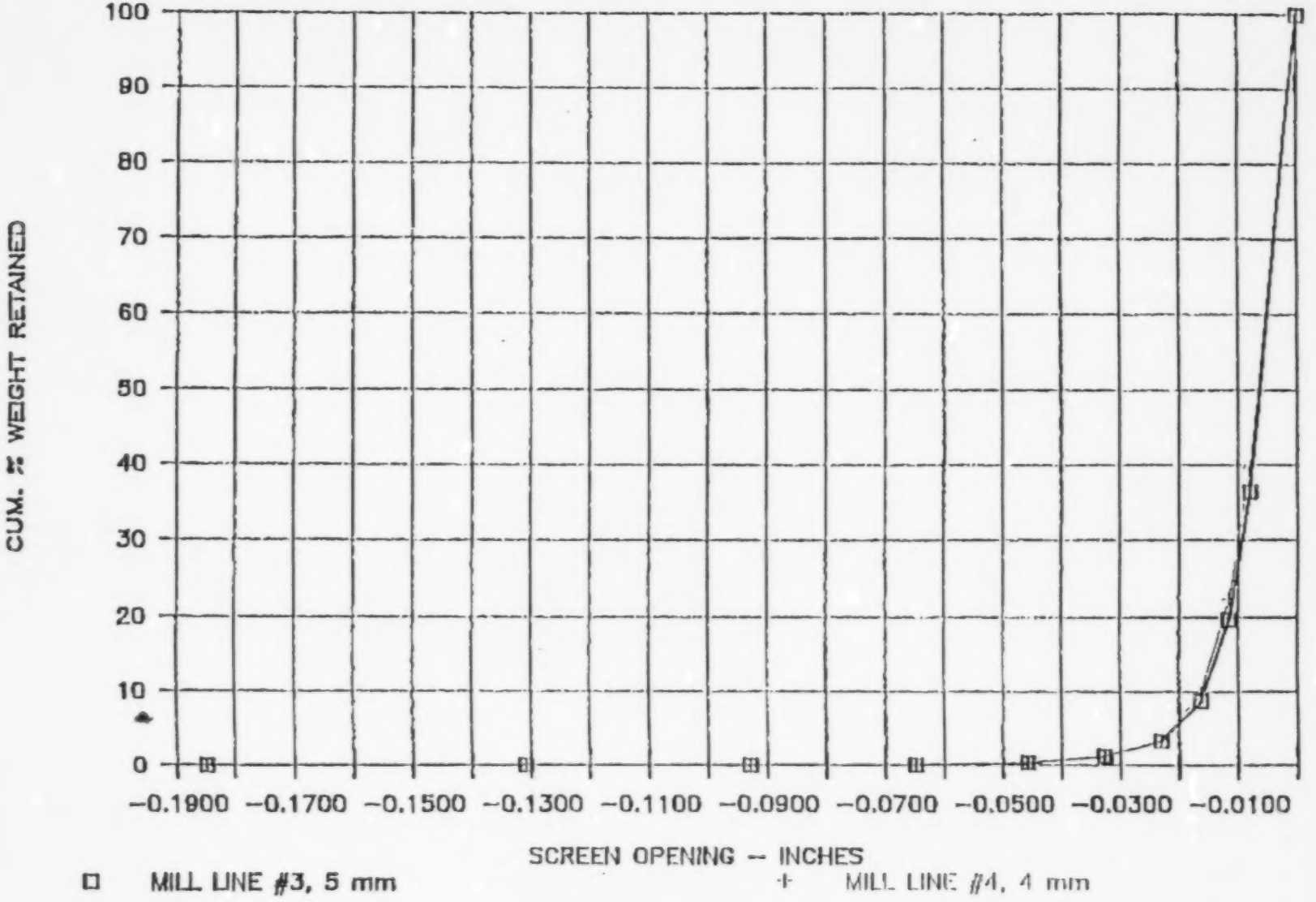

FIGURE IV: SIZE STRUCTURE COMPARISON OR SIZING SCREEN UNDERSIZE BETWEEN MILL #3 (5MM TROMMEL) AND MILL #4 (4MM TROMMEL).

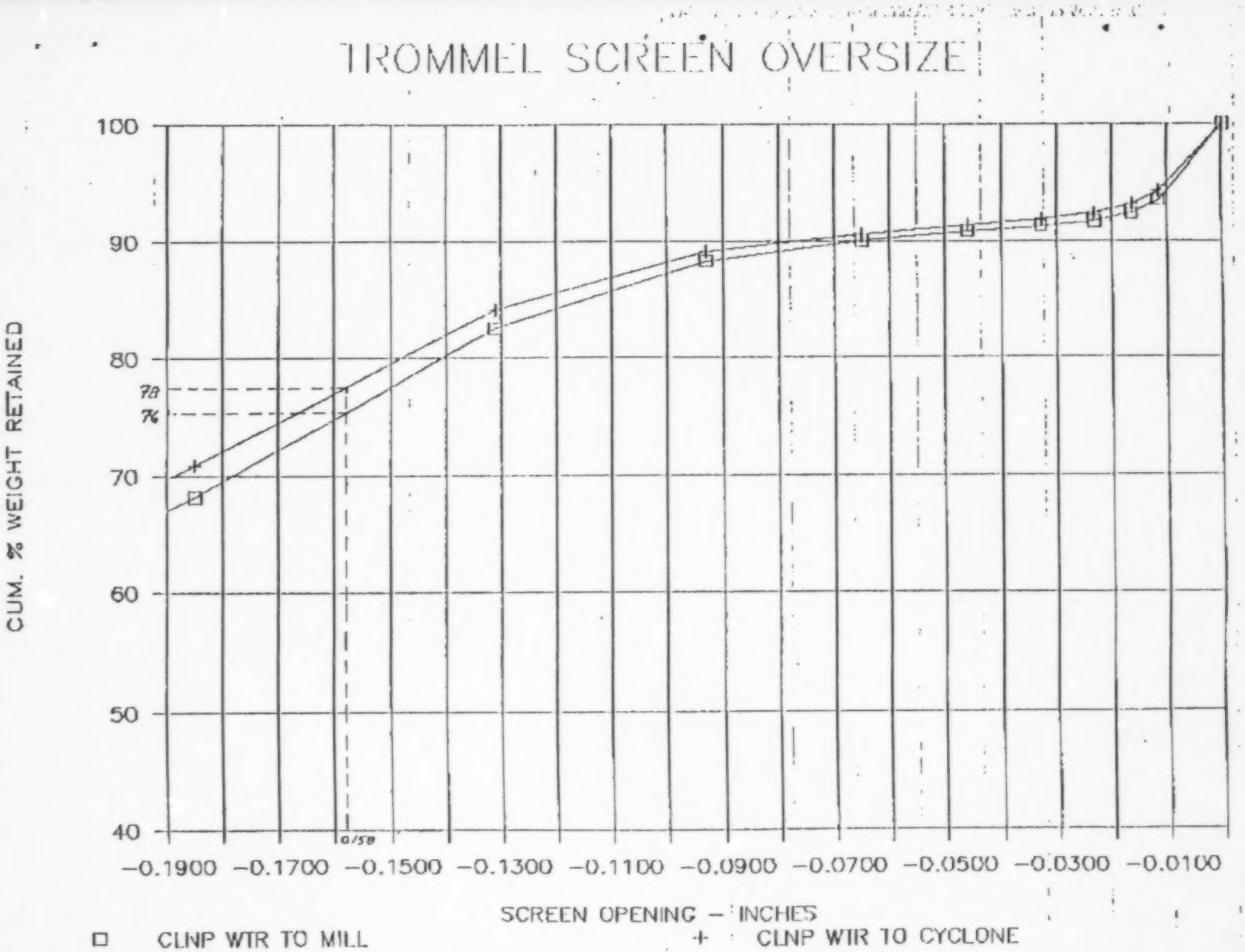

FIGURE V: SIZE STRUCTURE COMPARISON OF TROMMEL SCREEN OVERSIZE BETWEEN MILL #4 WITH & WITHOUT CLEANUP WATER.

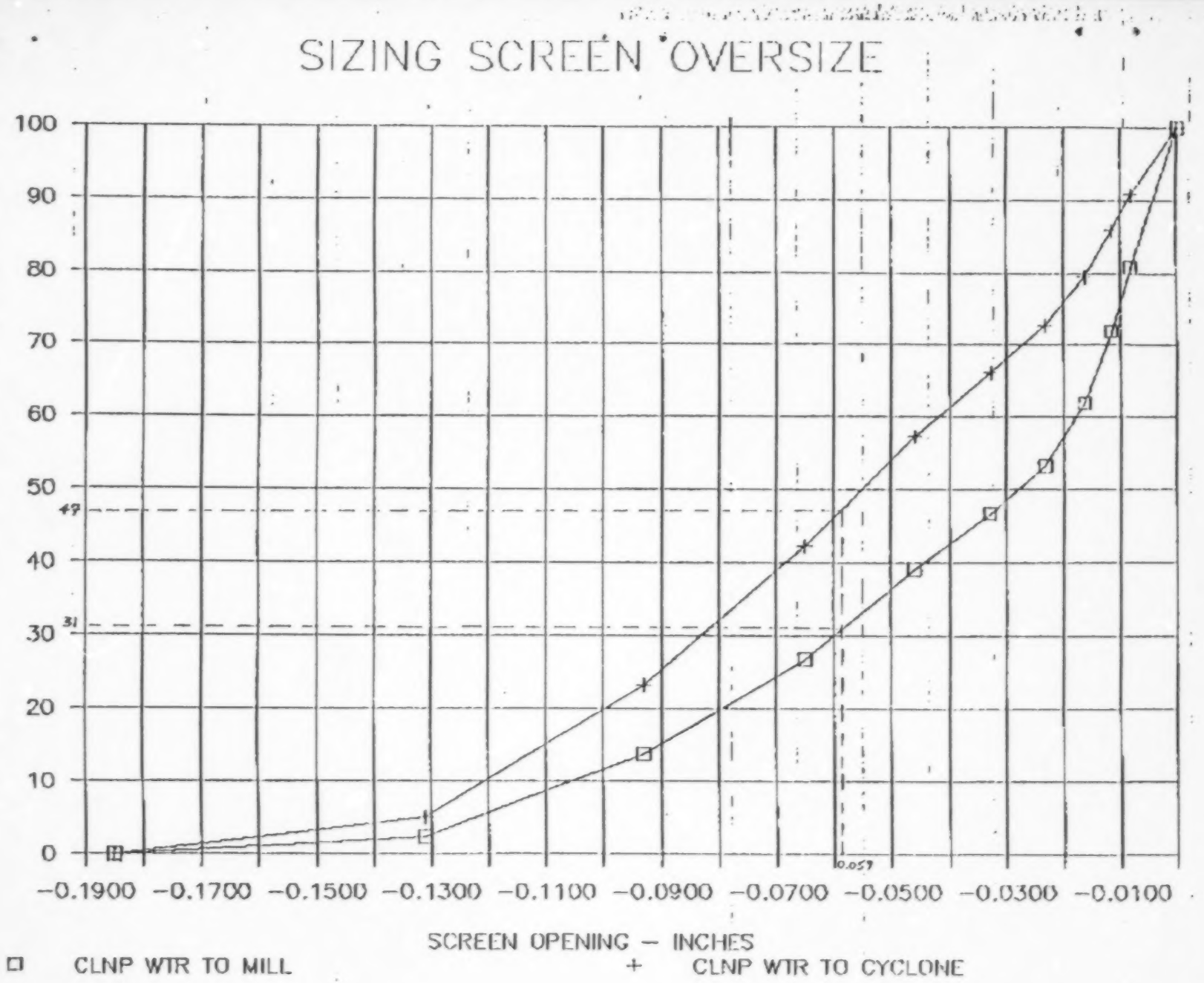

FIGURE VI: SIZE STRUCTURE COMPARISON OF SIZING SCREEN OVERSIZE BETWEEN MILL #4 WITH & WITHOUT CLEANUP WATER.

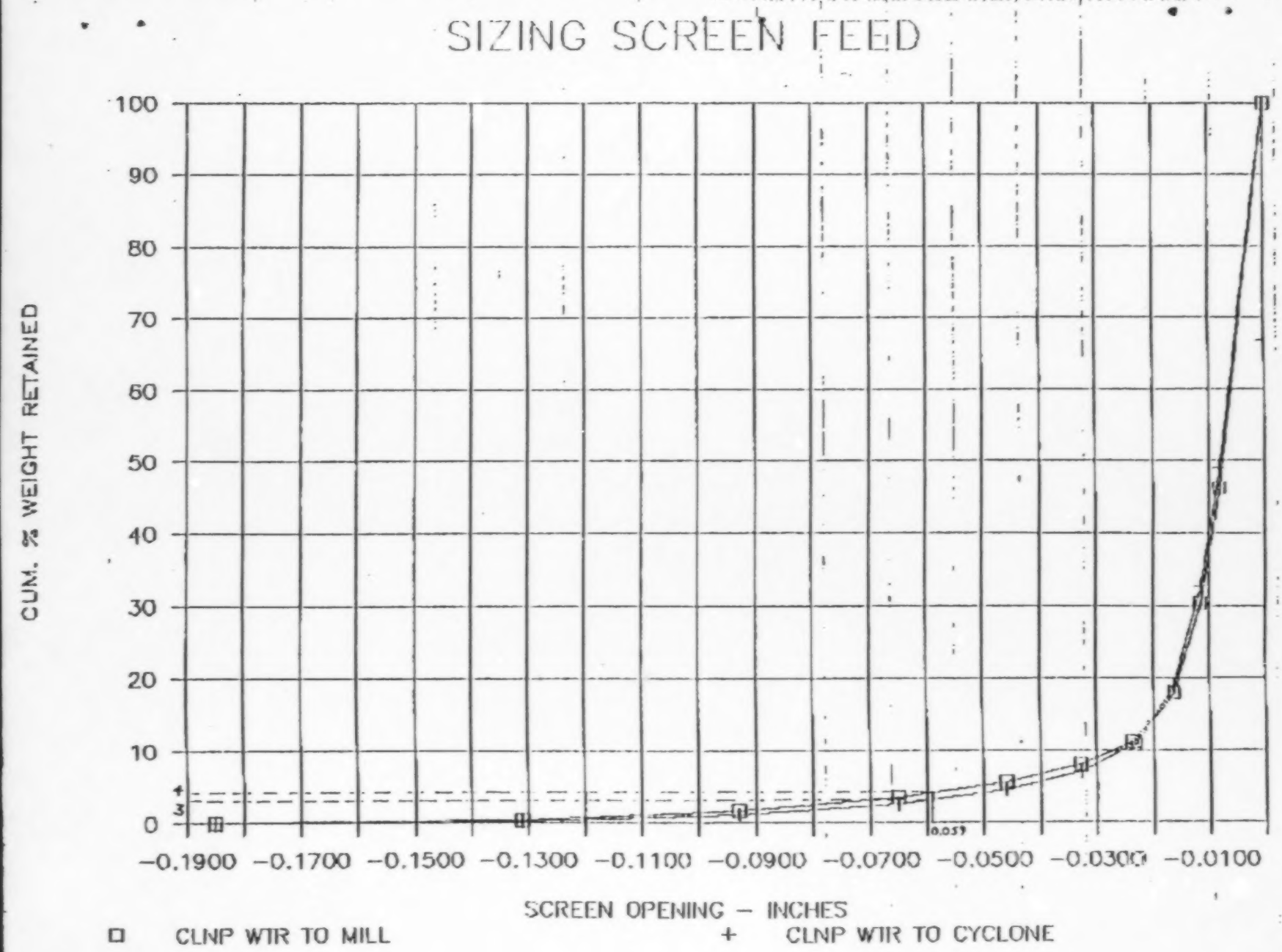

FIGURE VII: SIZE STRUCTURE COMPARISON OF SIZING SCREEN FEED BETWEEN MILL #4 WITH AND WITHOUT CLEANUP WATER.

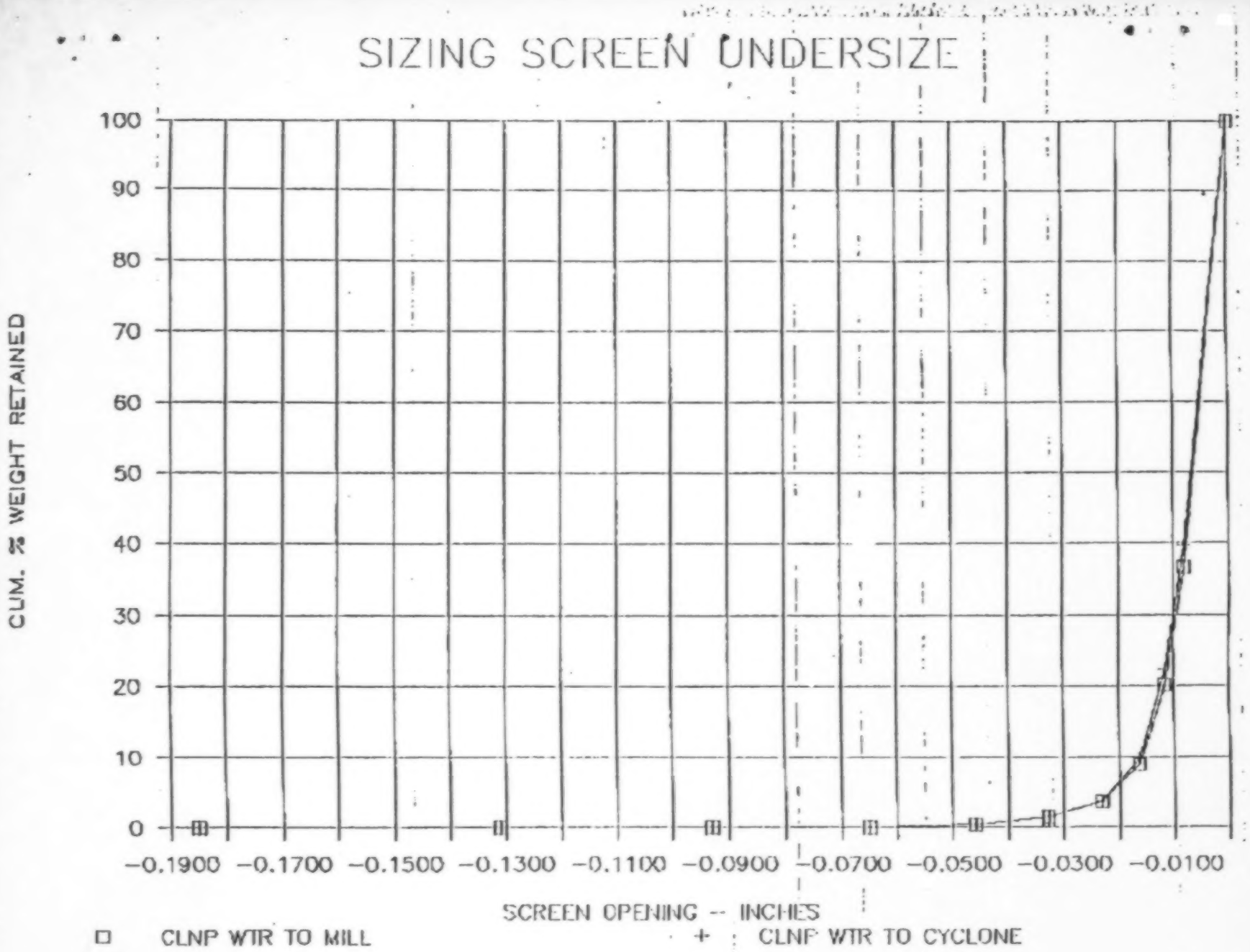

FIGURE VIII: SIZE STRUCTURE COMPARISON OF SIZING SCREEN UNDERSIZE BETWEEN MILL #4 WITH & WITHOUT CLEANUP WATER

APPENDIX I

Calculation of an efficiency equation from mass balance across a screen *

Consider a screen onto which there is a feed of F t/h, O t/h overflows from the screen and U t/h is the rate of underflow.

Let f = Fraction of material above cut point size in feed;
o = Fraction of material above cut point size in overflow;
u = Fraction of material above cut point size in undersize.

The mass balance on the screen is:

$$F = O + U$$

The mass balance of the oversize material is:

$$Ff = Oo + Uu$$

The mass balance of undersize material is:

$$F(1-f) = O(1-o) + U(1-u)$$

Hence:

$$\frac{O}{F} = \frac{f - u}{o - u}$$

$$\frac{U}{F} = \frac{o - f}{o - u}$$

The recovery of oversize material into the screen overflow:

$$= \frac{Oo}{Ff} = \frac{o(f - u)}{f(o - u)} \qquad \text{——— (1)}$$

..cont'd..

(Appendix I..cont'd..)

The corresponding recovery of undersize material in the screen underflow:

$$= \frac{O\,(1 - u)}{F\,(1 - f)}$$

$$= \frac{(1 - u)\,(o - f)}{(1 - f)\,(o - u)} \qquad \text{——— (2)}$$

The two relationships (1) and (2) measure the effectiveness of the screen in separating the coarse material from the underflow and the fine material from the overflow.

A combined effectiveness or overall efficiency E is obtained by multiplying the two equations together:

$$E = \frac{o\,(f - u\,(1 - u)\,(o - f)}{f\,(o - u)^2\,(1 - f)} \qquad \text{——— (3)}$$

Where 'u' is very small (3) may be reduced to:

$$E = \frac{0 - f}{0(1-f)} \qquad \text{——— (4)}$$

* Wills, B.A., Mineral Processing Technology, Permagon Press, Oxford,1981.